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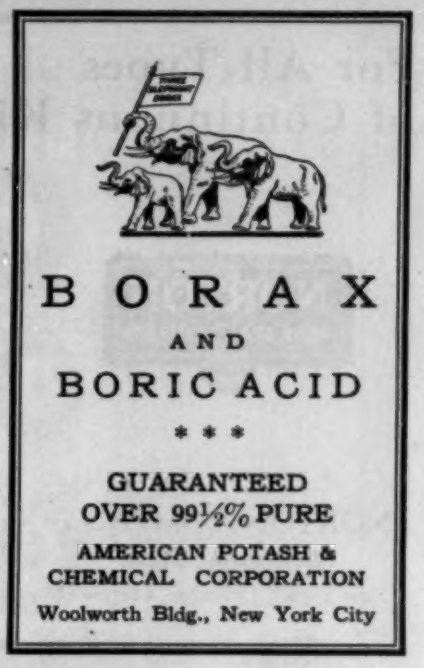

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SODIUM ALUMINATE AS AN ELECTROLYTE FOR CASTING-SLIP CONTROL*

By W. K. Carter and R. M. King

ABSTRACT

Sodium aluminate has been used as a water-softening agent, but not to any great extent in the ceramic industry. The results of this investigation show that sodium aluminate when used as a substitute for sodium carbonate in casting slips eliminates or minimizes some of the troubles usually encountered in the control of slips and in casting ware.

I. Introduction

The ideal electrolyte action should produce the following results: (1) give deflocculation of a type suitable to the production of good casting behavior; (2) give complete deflocculation within a reasonable time; (3) permit the maintenance of this slip condition by minimizing the effects ordinarily produced by the variable factors of time, temperature, and agitation during storage periods; (4) produce slips having definite relation between viscosity and casting behavior; and (5) give good casting behavior over a range of electrolyte concentration.

II. Procedure

(1) Plastic filter-press cakes of a commercial sanitary ware body were used for all slips.

(2) Definite control of specific gravity and of rate and time of blunging was maintained, the kind and type of electrolyte being the only variable.

(3) Mobility determinations were made on slips of varying electrolyte concentrations by means of a Gardner mobilometer.[1] This instrument consists essentially of a perforated disk on the end of a plunger which falls through a cylinder containing the slip. The time of fall for a definitely weighted disk and plunger through a slip at various stages of deflocculation gave the mobility-concentration curve.

(4) Casting behavior tests at various stages of deflocculation were made to determine (*a*) pouring behavior, (*b*) character of casting as to firmness, homogeneity, and porosity, (*c*) rate of casting, *i.e.*, thickness in a given time, (*d*) dry strength of castings, and (*e*) stability of slip on aging as to retention of original properties.

The condition of the cast pieces was used as a criterion of the casting behavior rather than the mobility values, which do not in many instances give a true indication. (See Figs. 1 and 2.) The curves show a wide range of electrolyte concentrations, having approximately the same

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* Presented at the Annual Meeting, American Ceramic Society, Washington, D. C., February, 1932 (White Wares Division).

[1] See G. H. McIntyre and J. T. Irwin, "Application of the Gardner Mobilometer to Enamel Slip Consistency Studies and Control," this issue *Jour. Amer. Ceram. Soc.*, p. 433.

mobility values but widely differing casting behaviors; and in other instances, varying mobility values, giving approximately similar casting behavior.

For a given mold condition the behavior may be determined fairly accurately by the thickness of the casting, but the best method is simply by feeling the casting while it is setting up. The best sanitary ware plant control is maintained almost wholly by this method. This "feel" is something that can be acquired only by experience. It was found that corresponding casting rates are uniform for ranges indicating best behavior. These determinations were checked by experienced plant operators.

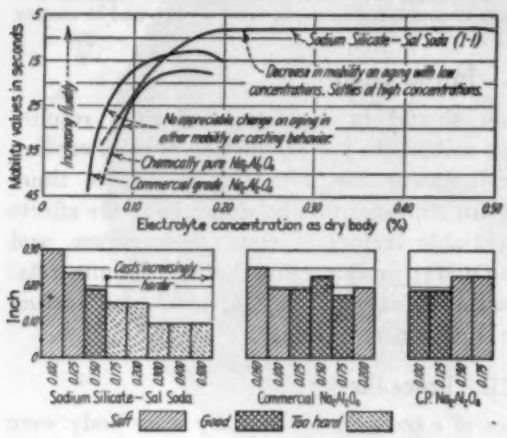

FIG. 1.

Figures 1 and 2 show the fluidity and casting behavior obtained with slips containing various concentrations of (*a*) commercial sodium aluminate, (*b*) chemically pure sodium aluminate, (*c*) commercial sodium aluminate and sodium silicate, and (*d*) sodium silicate and sal soda.

III. Analysis of Laboratory Data

(1) The permissible range of concentration as evidenced by casting behavior is greater for all slips containing sodium aluminate.

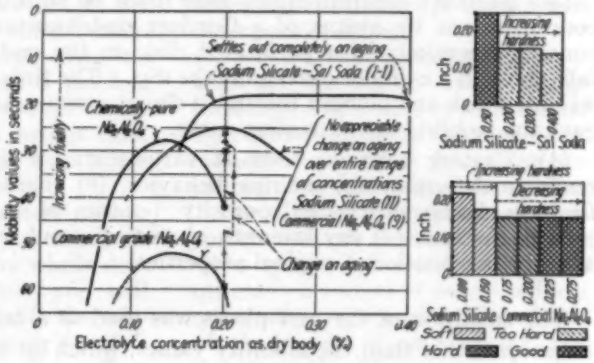

FIG. 2.

(2) With slips containing sodium aluminate the mobility is a much better indication of casting behavior, since sodium silicate and sal-soda slips undergo no apparent change in mobility over a long range of electrolyte concentration, but do show wide variations in casting behavior over this range.

(3) The changes of mobility and casting behavior due to aging show that slips containing sodium aluminate are much more stable.

(4) The dry modulus of rupture tests show that sodium aluminate gives a greater dry body strength.

IV. Plant Tests

Tests were made under actual plant conditions and supervision. It was found (*a*) that the deflocculating action of sodium aluminate was much slower than that of sodium silicate and sal soda; (*b*) that given sufficient blunging time, a satisfactory slip could be produced with a sodium aluminate content as low as 0.225%, (*c*) that the ware was entirely satisfactory; (*d*) that the slip cast firmly, drained well, had superior drying qualities, and remained plastic long enough to give ample time to finish the ware in the best condition; (*e*) that the dry strength increased 20 to 25% over the regular body containing nearly double the amount of electrolyte as sodium silicate and sal soda; and (*f*) that the slip showed no change in casting behavior or mobility on aging.

(1) Rate of Electrolyte Action While slow action might be an advantage, or at least no disadvantage in some cases, most plant requirements are for the slip to be used after two or three hours of blunging. A combination of 11 parts sodium silicate and 9 parts of sodium aluminate showed sufficiently rapid action and still retained to a large degree the advantageous features of sodium aluminate alone. The curve in Fig. 1 shows the action of this combination.

V. Summary

(1) Satisfactory slips were produced and ware was cast with the electrolyte content ranging from 0.23 to 0.30%, depending on the type of body. All phases of casting behavior were satisfactory.

(2) Satisfactory slips were produced and ware cast from the same body under the same conditions with variation in electrolyte content as great as 15%.

(3) Increased dry strength over that obtained with sodium silicate and sal soda was obtained in all trials.

(4) Superior drying and finishing characteristics were observed in all trials.

(5) Definitely increased stability of slip condition as to mobility and casting behavior was obtained in slips containing sodium aluminate or a combination of sodium aluminate and sodium silicate as compared with that produced by the use of sodium silicate and sal soda.

NOTE: W. K. Carter, senior author of this paper, is research engineer with the National Aluminate Corporation; R. M. King is assistant professor, Ceramic Engineering, Ohio State University, Columbus, Ohio.

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THE FLOW OF GLASS IN TANKS*

By F. C. Flint and A. K. Lyle, Jr.

ABSTRACT

The paper deals with the flow of glass in tank furnaces. Reference is given to previous work on this subject. Experimental data are given for water and other liquids and the physical principles are discussed. Illustrations indicate the direction of flow in a glass tank.

I. Introduction

Researches on the flow of glass in tanks by earlier investigators are as follows:

(1) H. Jebsen-Marwedel[1] observed the surface flow of glass by means of floating clay spheres. The speed ranged from 24½ feet per hour down the center to 10 feet per hour within 2 feet of the sides. Calculations based upon these observations and on the volume and weight of glass drawn from the tank indicated a surface stream depth of 1¼ inches average.

(2) W. König[2] using the same method,* observed surface speeds from 6½ to 45 feet per hour. His calculations accounted for only 90% of the moving stream and suggested that the apparently abnormal speeds observed were caused by the difference in temperature of more than 500°F between the melting and refining chambers of the tank. The flow was observed to be from regions of higher temperature to those of lower temperature along the surface. Beneath the surface the flow was reversed, *i.e.*, from regions of low temperature to higher temperatures. He considered the real cause of flow to be variations in the density which are caused by difference in temperature.

König did not go quite far enough in his explanation of the flow beneath the surface. The regions of lower temperature would have to be at the same or a higher gravity level to cause flow in the direction of increasing temperature.

By both top and bottom heating, the surface flow will be away from the hotter regions. The difference lies in the fact that in the middle portions of the liquid the flow will be toward the hottest region in the same plane in the case of top heating and away from it in the case of bottom heating.

(3) O. Stumm[3] observed the flow which was independent of the pull and also the transverse currents which pulled the spheres to within 75 centimeters of the sides.

(4) D. J. McSwiney[4] suggested that viscosity was the largest single factor in determining the depth of flow. He estimated the central channel to be 12 to 18 inches deep.

(5) G. V. McCauley,[5] in his studies of the flow of heat through furnace walls, observed in a cold tank evidence of strong sidewise glass currents. Since the temperature gradients existing during cooling of a tank are greater than during its operation and may not be in the same direction, this type of evidence presents, at best, an incomplete story.

(6) S. R. Scholes[6] made comparisons between pots and tanks and between tanks of various depths. He considered the effective flow to be only a few inches in depth.

(7) G. Gehlhoff, W. Schneekloth, and M. Thomas[7] determined the surface currents with floating spheres of clay, and by plotting the temperature distribution beneath the surface concluded that the full depth of the tank was included in the flow. They merely mentioned the effect of viscosity. The flow was unaffected by the drawing rate.

(8) A. L. Marden[8] used glass colored with cobalt to determine the flow in a small tank.

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* Presented at the Annual Meeting, American Ceramic Society, Washington, D. C., February, 1932 (Glass Division). Received March 14, 1932.

[1] *Glastech. Ber.*, **5** [5], 202 (1927); *Ceram. Abs.*, **7** [10], 671 (1928).

[2] *Glastech. Ber.*, **5** [9], 417 (1927); *Ceram. Abs.*, **7** [10], 672 (1928).

[3] *Glastech. Ber.*, **5** [6], 252 (1927); *Ceram. Abs.*, **7** [10], 672 (1928).

[4] *Glass Ind.*, **8** [7], 155; [11], 255 (1927); *Ceram. Abs.*, **6** [10], 433 (1927).

[5] *Jour. Amer. Ceram. Soc.*, **8** [8], 493 (1925).

[6] *Glass Ind.*, **9** [6], 126 (1928); *Ceram. Abs.*, **7** [8], 531 (1928).

[7] *Jour. Soc. Glass Tech.*, **15** [57], 12 (1931); *Ceram. Abs.*, **10** [8], 553 (1931).

[8] *Jour. Soc. Glass Tech.*, **15** [58], 119 (1931); *Ceram. Abs.*, **10** [10], 685 (1931).

(9) Bowmaker and Cauwood[9] added barium oxide to the batch. Analysis of samples from the feeder showed barium oxide in ten hours. The maximum added was never found in the glass. They did not consider the change in density caused by the barium addition.

(10) W. M. Hampton[10] added barium oxide to the batch to produce 1% in the glass. The addition was continued until a constant amount was found by analysis. Calculation of the results indicated strong convection currents and a marked surface flow.

(11) F. C. Flint[11] added manganese dioxide to the batch in a tank melting 60 tons of glass in 24 hours and observed a distinct color in the finished bottles after 5 hours. At the end of 11 hours the color was gone.

II. Summary of Previous Work

Surface flow has been observed accurately and speeds from 6 to 45 feet per hour have been observed. König was the first to establish the cause of the flow as due to difference in density. The surface flow is away from regions of high temperature and toward regions of lower temperature.

The depth of flow has been estimated at $1^1/_4$ inches by calculation and also at the full depth of the tank. Actual evidence indicates a fast moving top stream.

The surface flow seems to be unaffected by the drawing rate.

III. Flow Due to Density Differences

A glassmelting furnace constructed with melting and refining chambers separated by a bridge wall presents two sets of conditions. The melting chamber is heated from the top. The refining chamber at a lower temperature receives its heat by radiation from the melting chamber and by convection of the hot glass through the flow hole from the melting chamber. Glass entering the refining chamber is hotter than the main body of glass already present and, since this hot glass enters at the bottom, the refining chamber is essentially heated from the bottom.

In a vessel heated at the bottom the liquid rises vertically from the region of greatest temperature and descends at the sides to complete the flow. The flow is caused by changes in density of the heated liquid. The liquid at the bottom where the heat is applied becomes lighter and is then displaced by the heavier liquid surrounding it.

When a liquid is heated from the top the results are changed. Two special cases of top heating may be examined. Suppose the top surface of a liquid to be heated uniformly so that every point in the surface will be at the same temperature and every point in a plane beneath the surface and parallel to it will be at a uniformly lower temperature than the surface. Under these conditions every particle of liquid will have a heavier particle beneath it, a lighter particle above it, and particles of the same density surrounding it at the same level. This is a state of mechanical equilib-

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[9] *Jour. Soc. Glass Tech.*, 15 [58], 128 (1931); *Ceram. Abs.*, 10 [10], 685 (1931).
[10] *Jour. Soc. Glass Tech.*, 15 [59], 251 (1931); *Ceram. Abs.*, 11 [2], 87 (1932).
[11] Unpublished results.

rium, and no flow will occur. Figure 1*A* shows the liquid divided into layers of uniform density and at the same time uniform temperature.

If a glass tank were heated so that this special condition existed, convection currents would not be a problem, and the only flow would be due to the mechanical feeding of the batch or the drawing of the melted glass.

Suppose a liquid to be heated from the top so that at one point on the surface the temperature is greater than at any other. The planes of equal density will then be curved or bent, and the point of highest temperature will be at a higher level than any other. (See Fig. 1*B*.)

This is obviously not a state of equilibrium. A particle of liquid at the point of highest temperature, which is also the point of lowest density, will flow "down-hill" displacing the lighter fluid flow below it, air or furnace atmosphere, as the case may be. From this point or line of lowest surface-temperature, this particle will continue to flow "down-hill" toward a point beneath the hottest portion displacing the lighter fluid below it, in this case liquid of lower density. When the bottom of the "hill" is reached, the particle will be just below the source of heat. It will then receive heat, become less dense, and be displaced by some other particle more dense and thus rise to the starting point. Figure 1*C* illustrates this flow.

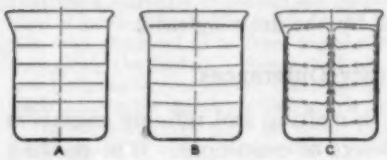

FIG. 1.—*A*, uniform top heating; *B*, top heating with highest temperature at center; *C*, lines of flow with liquid heated as in *B*.

The surface flow is much faster than any of the return flow even if the liquid did not vary its viscosity with change in temperature, since applying the principle of continuity the total subsurface flow must equal the surface flow, and the total flow, considering the return flow negative, must be zero. The flow of glass in the lower layer would be retarded by the viscosity increase with decrease in temperature. As to the depth of the surface stream only an estimate can be made. Stumm's calculation of $1^1/_4$ inches may be very near the truth.

It may be noted here that the net flow, considering any depth of liquid less than the whole depth, is away from the point of highest temperature. This may account for the better results obtained by Stumm with small clay balls in the case of glass flow.

This theory of flow based on a decrease of density with an increase of temperature can apply only to pure liquids or to associated liquids which decrease in density with increase in temperature. If glass at certain temperatures or composition increases in density with increase of temperature the only change would be in the direction of the flow. That glass, which is by no means a pure liquid, behaves in the proper manner may

be assumed from the direction of the surface flow which is always away from the region of highest temperature. (See footnotes 2, 3, and 7.)

IV. Flow of Water Due to Density Difference

Beakers of water heated in various manners served to show the convection currents caused by temperature (density) differences. The flow was made apparent by a dark dye added to the water.

With the top surface of the water heated over a small area by a hot rod just touching the surface, convection currents were confined to a layer one-half inch thick. The color was maintained within this layer for approximately one hour. (The unheated beaker became uniformly colored in fifteen minutes.) The flow was away from the hot portion toward the colder sides, down the side a short distance and back again to the starting point. The velocity was not constant, decreasing with distance from the hot spot, and the return flow was much slower than the surface flow. When this water was heated from the bottom, the color became uniform rapidly, the convection currents being very fast and including the whole liquid.

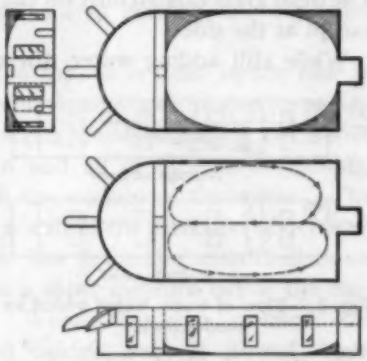

FIG. 2.—Shaded areas indicate dead corners; arrows indicate direction of flow.

With paraffin and castor oils the layer of dyed liquid became much deeper than it did when water was used. After heating castor oil from the top for one hour, the band of color was about two inches deep at the side of the beaker. At the center the dye was still concentrated near the top. All of the subsurface flow was away from the side and toward the warmer center. The depth of the return flow is governed by the difference in temperature between the liquid and the sides of the container. Starting with the liquid at room temperature the lower boundary of the return flow is just below the surface. As the temperature increases the cooling effect of the sides becomes more of a factor and the dyed liquid falls to a greater depth while returning.

V. Flow in Model Tank

To gain knowledge of the behavior of fluids under conditions approximating those ordinarily found in a glass tank, experiments were conducted in a small metal tank having approximately the same proportions as a glassmelting furnace.

The melting end is 15 inches long by 10 inches wide (Fig. 2). The

refining end is a semicircle of 5-inch radius. A bridge wall with a flow-hole $^1/_2$-inch square cross-section separates the two parts. Glass windows are placed at intervals along the two sides and ends as indicated. The bridge wall could be cooled with a stream of cool water.

Experiments were first conducted in the model tank to discover the natural flow of water through it under uniform temperature conditions. The tank was filled with water and the melting end was made very dark by a blue dye. Uncolored water at the same temperature as that in the tank was added slowly at the dog house so as to cause dropping at the spouts. After some sixteen hours of flow the tank contained clear water except in the corners of the melting end which still contained blue water. The refining end was a uniform water-white color indicating that no more blue dye was being washed from the tank other than that due to diffusion. The dead glass existed only on the bottom and did not have much thickness except at the sides.

While still adding water, the color was changed to blue. The course of its flow followed closely the pattern outlined by the dead corners. The water moved forward from the dog house toward the bridge wall. It divided at the bridge into two streams each returning along the sides toward the rear of the tank and rejoining the central forward flow. The bridge wall was not cooled during this experiment.

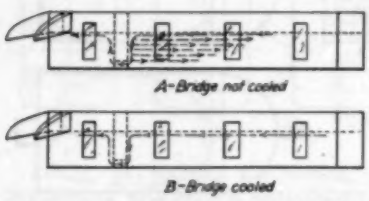

FIG. 3.—Flow of warm water added to model tank.

To the tank filled with water at room temperature, hot water containing blue dye was added; the bridge wall was cooled with water. The flow was along the surface only. At the bridge wall the warm colored water dropped and flowed through the flow-hole of the bridge. On emerging in the refining end it rose and resumed its surface flow through the spouts and out. This experiment could be continued for an hour or so without any appreciable coloring of the colder water.

With the bridge wall uncooled, the same experiment produced a different result. The surface flow was the same but, instead of dropping as it reached the bridge wall, it returned slightly below the surface. As the experiment continued, the tank gradually filled with blue water from the top downward. None of the blue water entered the refining end until that in the melting end had reached the opening of the flow-hole. (See Fig. 3.)

It should be noted that the melting and refining chambers of the tank were at the same temperature, whereas the refining chamber of a glass furnace is usually at a lower temperature than the rest of the tank.

Hot blue water containing Karo to make it heavier was added. This

dropped to the bottom and flowed forward to the flow-hole and into the refining end. When a one-half inch layer of the heavy blue "glass" covered the bottom, hot water containing blue dye was added without disturbing this lower layer. The flow in this case was identical with the previous experiments with hot blue water. As the blue stream ducked through the flow-hole, it mixed with the heavier bottom layer and caused some mixing in the refining end. The "glass" in this case was noticeably cordy. The main part of the bottom layer was not disturbed. (See Fig. 4.)

FIG. 4.—Flow of warm water when bottom is covered with a layer of heavier liquid.

In the operation of a glass tank, it has been noticed that a composition change which decreases the density causes cords which persist for two or three days. If the change causes an increase in density, the cords are much worse, but last only a few hours.

To heat the water in the tank from the top, as is done in the case of glass, a frame holding six carbon filament lamps was placed over the melting end only. The top part of the water could be heated 10° above room temperature. With the tank filled and all of the lamps burning, blue dye was added at various points on the surface of the water. The flow was always toward the sides or bridge wall in the direction of decreasing surface temperature. At the sides the flow descended a short distance and then returned to the warmer portion a short distance below the surface. When the dye reached the cooled bridge wall, it flowed down and through the flow-hole and rose again in the refining end. At the outside walls of the refining end, the dyed water descended to the bottom, flowed along it to the flow-hole and back again into the melting end, quite independent of the flow in the opposite direction. In this case the body of liquid in the melting chamber was at a higher temperature than the refining end. It is possible that the flow in a glass tank is independent of the drawing rate. As was the case in the beaker, the subsurface flow was very much slower. With only three of the lamps burning on one side, the flow of the water was not much changed. When the blue dye was dropped in the front portion of the melting end, the flow would be toward the cooled bridge wall. (See Fig. 5.)

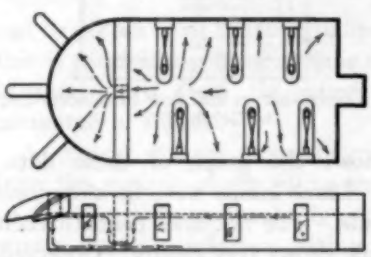

FIG. 5.—Flow in the model tank when heated from the top.

With the tank heated by three lamps on one side, water colored red was added to the tank dropwise. Flow in this case was along the surface on

the side away from the lighted lamps. As it reached the side of the tank, it dropped one-half inch or less and returned diagonally toward the bridge wall. After this had continued for some time, one side of the tank was colored red while that portion beneath the lighted lamps was not colored at all. The lamps on the opposite side were then lighted and blue water added. With this change the red part remained almost stationary while the blue flowed along the other side. The temperature of both of the colored waters was somewhat below the temperature of the water already in the tank. The division between the red and blue sides of the tank was quite distinct.

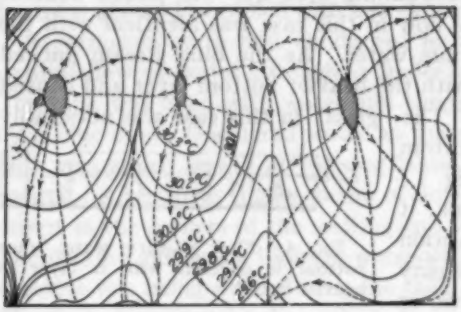

FIG. 6.—Temperature distribution on surface of model tank heated by three lamps; broken lines indicate flow.

An attempt was made to get complete thermal data of the model tank containing water heated under definite conditions. Due to unavoidable mixing of the water and to the difficulty of maintaining constant temperature distribution, only the surface temperatures could be measured with any degree of accuracy. Figure 6 shows the graph of these data. Three lamps were lit along one side. The hot area beneath each one shows very clearly. Observed surface flow followed the lines as indicated.

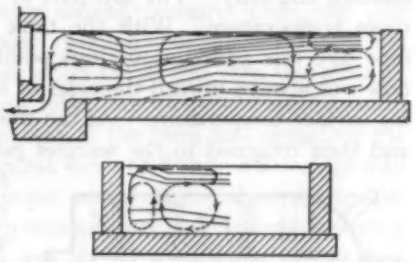

FIG. 7.—Isotherms and flow lines according to Gehlhoff.

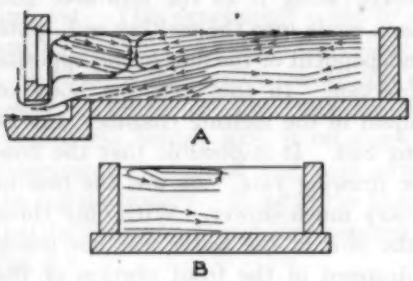

FIG. 8.—Flow lines drawn according to density differences from data by Gehlhoff.

VI. Estimated Flow in Glass Tank

For purposes of application Gehlhoff's thorough data have been used. Figure 7 is a reproduction of Gehlhoff's flow lines down the center of a tank and shows the subsurface flow to be very deep. It is important to note that his lines represent only the direction and not the speed of flow.

Figure 8*A* is the same tank, but the flow lines are drawn according to the density differences. Here a deep forward flow is evident. The circulating stream is only effective to half the depth of the tank, and the surface flow is quite shallow. At the side of the tank, Figure 8*B*, the flow is confined to a small depth. This sidewise flow may be a large factor in the solution of clay blocks at the surface line.

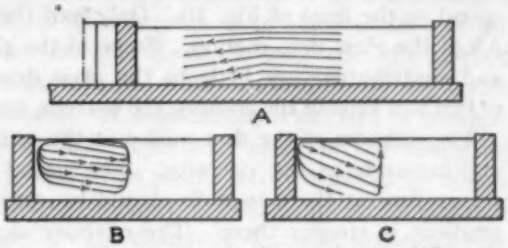

FIG. 9.—Flow lines according to density differences from data by Gehlhoff.

Figure 9*A* shows the longitudinal cross-section of the same tank one-third of the width from the center. There is still evidence of some forward flow.

Figures 9*B* and 9*C* are cross-sections and indicate the convection current near the side. The flow lines drawn in any particular plane can represent only the component of flow in that plane. Probably the best picture of the flow in a single plane can be gotten from the longitudinal cross-section through the center, since this is most likely to be a plane of symmetry. Figure 10 shows the flow as interpreted from the same data presented in Fig. 8.

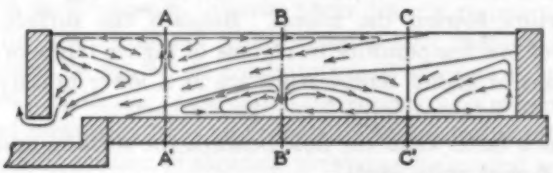

FIG. 10.—Flow lines drawn from the same data as Fig. 8 (longitudinal cross-section).

A central stream flows diagonally from the surface of the filling-on end to the flow-hole in the bridge. This stream does not interfere with any of the circulating streams and does not disturb the surface flow. The downward flow at the line *C-C'* may be attributed to the cooling effect of the unmelted batch. At the line *B-B'* the flow is upward from the bottom and is complimentary to the flow at *C-C'*. At *A-A'* the surface temperature is highest. From this point the surface flow originates and includes nearly the whole area of the tank.

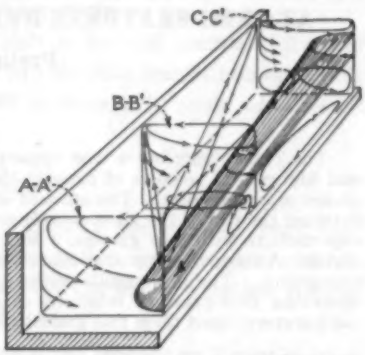

FIG. 11.—Three-dimensional flow constructed from planes of flow.

It is rather difficult to get from separate planes an accurate picture of a

three-dimensional flow. Figure 11 may not clarify the picture, but it does indicate the complications. The planes AA', BB', and CC' correspond to the lines of Fig. 10. Only half the width of the tank is shown. All of the glass is in motion. Some of the glass moves in a closed circuit and contributes very little to the glass drawn from the tank. Regions of this sort exist in the corners, the bottom, and near the side walls.

The velocity of the flow varies as the temperature or density gradient and inversely as the viscosity. The fastest flow is at the surface. The return flow at the side walls should be very rapid since the temperature gradient is steeper there. The effective depth of the flow through the center may be estimated at half the actual depth of the tank. At the sides the effective depth is very small.

VII. Summary

Convection streams caused by temperature differences in liquids are due to differences in density.

When a liquid is heated from the top, the flow is from the region of highest surface temperature toward the lowest. Beneath the surface, the flow is from regions of low temperature to regions of higher temperature, providing the regions of higher temperature are at a lower gravity level.

The surface flow is much faster than the flow beneath the surface, and the depth of the surface flow is quite small.

HAZEL-ATLAS GLASS COMPANY
WASHINGTON, PA.

PRECISE MEASUREMENTS OF THE VISCOSITIES OF GLASSES AT TEMPERATURES NEAR THEIR ANNEALING POINTS*

(Preliminary Report)

BY H. R. LILLIE

ABSTRACT

The paper describes a new apparatus for measuring glass viscosities of 10^{13} poises and higher. It consists of causing the glass flow to take place inside a steel tube by means of air pressure. The amount of flow is observed by means of interference fringes between the top of the glass sample and a stationary plate of fused silica. Preliminary experiments with two glasses, a lime and a light flint, are described and the results given. A comparison is also made between results by this method and by that of fiber elongation. The new results indicate that the apparatus can be successfully used for observing flow-pressure relations at extremely high viscosities and also that at the temperatures used these two glasses are purely viscous liquids.

I. Introduction

In a recent report[1] the method in use for routine measurements of the

* Presented at the Annual Meeting, AMERICAN CERAMIC SOCIETY, Washington, D. C., February, 1932 (Glass Division). Received May 11, 1932.

[1] H. R. Lillie, "Viscosity of Glass between the Strain Point and Melting Temperature," *Jour. Amer. Ceram. Soc.*, **14** [7], 502 (1931).

so-called annealing and strain points of glasses was described. For this type of measurement, where the object is solely to observe the temperatures at which predetermined rates of fiber stretch take place under definite conditions of temperature gradient, fiber diameter, load, etc., the method described has proved to be satisfactory and yields results directly applicable to the fixing of annealing schedules. It is essentially a method for measuring high viscosities and, as previously reported, values for the viscosities corresponding to the annealing and strain points were estimated by means of a derived formula, corrected approximately for the temperature gradient along the length of the fiber and for the change in diameter accompanying the stretch.

For the computation of absolute viscosity and observation of flow-stress relations as a function of both temperature and time, however, the previous method is not ideal in many ways and the need has been felt for a more precise method. To be useful, such a method must be based upon proven principles and the results obtained must be capable of expression in such terms as to make them directly comparable with those published for more ordinary viscous and plastic materials. Further, the method must be subject to computation of absolute values without the necessity of a multitude of estimated corrections, as is so common in present methods of measuring high viscosities. The apparatus must be so designed that a wide variation of shearing stress may be applied and the resulting deformations observed accurately both in form and magnitude. If such can be accomplished it is felt that a great deal may be learned about the constitution of glass simply by knowing how its yield point (if any) and viscosity, as shown by flow-pressure diagrams, depend upon temperature and perhaps time of treatment at certain temperatures.

The apparatus to be described, in which a limited number of runs have been attempted, represents an effort to meet the conditions outlined. More experience with the apparatus will be necessary to show whether or not these conditions are fully satisfied.

II. Apparatus

(1) "Plug" Method

Bingham has found that in the case of very viscous fluids such as tars, rosins, and pitches, correct values for absolute viscosity can be obtained by the use of a rather special form of capillary flow. This method is as follows:

The liquid is allowed to freeze into a glass tube some 2 or 3 centimeters in diameter, so as to form a plug a few centimeters in length near the center of length of the glass tube. Gas pressure is then applied to one end of the plug and the flow observed by measuring the deformation of the opposite surface.

In Bingham's work the displacements were large enough to be easily

measured directly. He found that by simply applying the same equations as are used for capillary flow, the absolute viscosities were in very close agreement with those found by other methods. This "plug" method can therefore be relied upon.

(2) Viscometer Proper Figure 1 shows the essential parts of the viscometer used. The glass is contained in a stainless steel cylinder grooved as shown on the inner surface to prevent slippage of the glass. This cylinder screws into the lower member (also of stainless steel) and is made tight by means of a soft copper gasket and water glass. A pressure inlet is welded into the lower member.

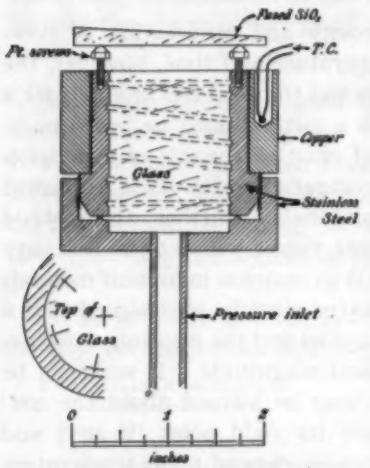

FIG. 1.—Viscometer proper.

The top of the glass is ground and polished to an optical flat as nearly as possible. Above this surface a fused silica plate is supported on three platinum screws. This plate is in the form of a wedge to prevent direct reflection and visible interference between its faces. The steel cylinder is surrounded by a heavy collar of copper which is assumed to come to the average temperature of the sample, this temperature being read by means of the calibrated chromel-alumel thermocouple (T.C.) and a Leeds & Northrup type K potentiometer.

In order to facilitate the counting of interference fringes, the top of the glass is etched as shown in the small sketch in Fig. 1. This gives one center point and six outlying points of reference.

(3) Preparation of Samples The glass is melted in a small porcelain crucible and poured into the steel cylinder, the latter having been previously heated to about 400°C in order to make the glass stick tightly to the metal. Care is taken not to trap air bubbles during the pouring. The whole is then quickly transferred to a furnace at about 800°C and allowed to remain at this temperature for about 30 minutes before being annealed in the same furnace. When the sample is finally cold its top is ground, polished, and etched with the reference points already mentioned.

(4) Assembly of Apparatus Figure 2 shows how the apparatus is assembled. The furnace element is composed of a length of iron pipe upon which the nichrome heating wire is wound. Automatic temperature control is maintained by a platinum control couple with its junction near the windings. A turned plug of

Sil-O-Cel brick insulates the bottom of the furnace while another plug made of alundum cement, upon which rests a plate glass cover, serves to decrease heat loss from the top of the furnace. With the furnace in steady operation no variation in the temperature of the measuring couple can be detected on the type K potentiometer.

Figure 2 also shows diagrammatically the simple interferometer system. Light from a mercury arc is filtered to allow only the green (5461Å) radiation to pass. This part is reflected from a plate glass (no silver), thence to a silvered mirror, and finally comes to focus on the sample. Interference takes place between the sample and the bottom of the fused-quartz wedge, thereby forming the fringes which may be observed through the reflecting plate glass by means of a telescope as indicated in the figure.

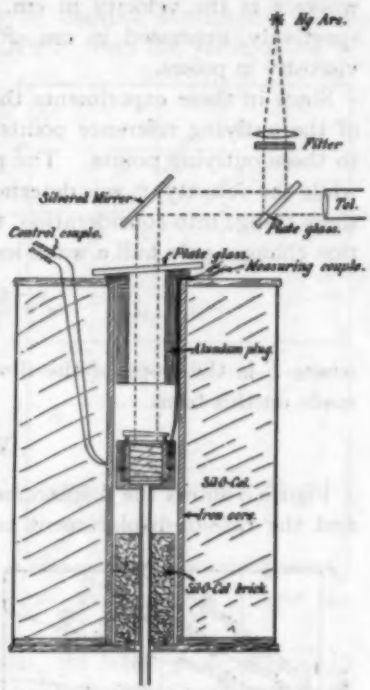

FIG. 2.—Assembly of viscometer.

III. Method of Observation

The present auxiliary interferometer apparatus permits only visual observations, the accuracy of which is limited by the fact that the fringes are often very close together and extremely difficult to count. The accuracy of each individual count is estimated at half a fringe while that of the average of the several counts from the various outlying reference points to the central reference point is probably about 0.2 fringe. A photographic system is now being considered which will increase this accuracy and at the same time permit a study of the form of the flow distribution in the sample.

The fringes are counted periodically (depending on the rate of flow) from the six outlying reference points to the central point. These counts are averaged in such a way as to give the relative displacement of the central reference point. This relative displacement is then plotted against time for any given pressure and temperature. The slopes of several such plots corresponding to several pressures at the same temperature may be used in plotting a flow-pressure curve which, in the case of a purely viscous substance, should be linear and through the origin, its slope being proportional to the viscosity.

IV. Computing Absolute Viscosities

If the liquid in a tube is subjected to a pressure parallel to its axis, it can be readily shown that the velocity of the liquid at the axis of the tube is expressed by

$$v = \frac{R^2 P}{4L\eta}$$

where v is the velocity in cm./sec., R and L, the radius and length, respectively, expressed in cm., P the pressure in dynes/cm.,[2] and η the viscosity in poises.

Since in these experiments the v measured was relative to the velocity of the outlying reference points, R was measured from the central point to these outlying points. The pressure, P, was expressed in atmospheres while the velocity, v, was determined in terms of fringes per hour. Taking these things into consideration, together with the fact that the glass elevation changes only half a wave-length per fringe, it is found that

$$\eta = \frac{1.93 \times 10^{13}}{S} \text{ poises}$$

where S is the slope of the flow-pressure curve. All computations were made on this basis.

V. Results

Figure 3 shows the displacement *vs.* time relations for various pressures and the rate-of-displacement *vs.* pressure relation for an ordinary soda-lime glass at 511°C. The annealing point of this glass, as determined by fiber elongation, is 510°C. The size of the plotted points indicates roughly the supposed accuracy of the readings. The slopes, s, of the displacement *vs.* time lines are indicated on the graph, expressed in fringes per hour. The curve for 0.48 atmosphere is drawn to indicate the slope computed from an overnight run, the observed points being too far separated in time to allow plotting. These slopes were then plotted against pressure as shown and the value of S in fringes per hour per atmosphere was found as indicated on the graph. The small effect of gravity acting against the gas pressure has been neglected here since it is in the order of 0.01 atmosphere.

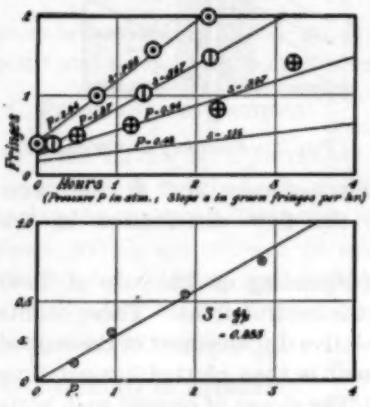

FIG. 3.—Flow relations in lime glass at 511°C.

Figure 4 shows the results of a similar run made on a light flint glass at 431°C. Its annealing point had previously been determined as 425°C.

The following table shows the results obtained in the preliminary work performed so far.

Glass	Temperature observed	η observed $\times 10^{-13}$	Annealing point	η at *A.P.* $\times 10^{-13}$	ΔT
Lime	511°C	6.8	510°C	7.4	12°C
Flint	431	2.8	425	4.5	6

Value computed from fiber elongation 2.5

In the above table ΔT is the number of degrees centigrade which corresponds to the deviations of the "η at *A.P.*" from the value of 2.5×10^{13} poises previously estimated from fiber elongation.

VI. Discussion

(1) Observations The observations indicate that the method is applicable to accurate measurements of flow characteristics in glass at temperatures of high viscosity. They indicate further that by the addition of photographic means of making observations the accuracy may be increased considerably.

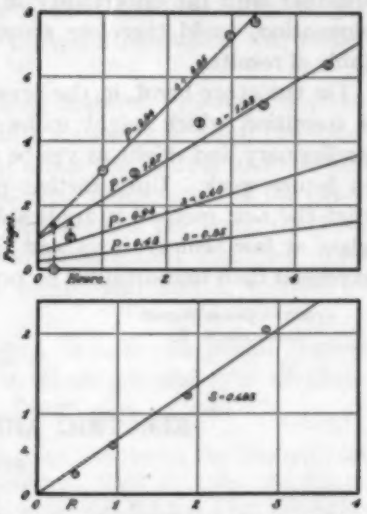

FIG. 4.—Flow relations in light flint glass at 431°C.

It is evident, also, that these two glasses, at the temperatures of measurement, are both truly viscous liquids since, approximately within the limits of error, the displacement *vs.* time relations and the rate-of-displacement *vs.* pressure relations are all linear, the latter passing through the origin in both cases. The question as to whether this continues to be true as the temperature is lowered appreciably can be investigated by extending the runs to long lengths of time and making more accurate observations by the aid of photography.

(2) Results The purpose of this preliminary report is to describe the method being developed and not to present new results. It is quite impossible to say in the present report what interpretation can rightly be put on the comparison of values listed in the above table, since the comparison is between glasses of rather different properties and between methods entirely different in principle.

It is not impossible for this disagreement between absolute values to be entirely traceable to conditions which surround the determination of annealing points and give rise to errors which are negligible in connection

with plant practice but which would make an appreciable difference in the present connection. The annealing point has been arbitrarily defined as the temperature at which a glass reaches a fluidity equal to that of a standard glass at its temperature of specified annealing rate. To this definition has been added the assumption that equal rates of total fiber stretch signify equal viscosities, regardless of actual temperature or rate of change of viscosity with temperature. But in a system influenced by temperature gradients (dependent in magnitude upon temperature itself) this rate of change of viscosity will affect the ratio between observed total elongation and real mobility at the hottest point of the fiber. This fact, together with the uncertainty in computing absolute viscosity from fiber elongation, could therefore account for all the differences shown in the table of results.

On the other hand, in the present work the glass was somewhat seedy, a condition which might make for high results. The experiments are preliminary and might as yet be subject to errors which will be overcome in future work. Until further runs are made it can only be concluded that the new method is applicable to the study of flow-stress relations in glass at low temperatures and that by its use one can hope for greater precision than that attained by previous methods.

CORNING GLASS WORKS
CORNING, N. Y.

ELECTRIC ANNEALING OF GLASS*

BY R. M. CHERRY

ABSTRACT

The total and distribution heat requirements are discussed in general as well as the manner in which electric leers economically meet these requirements based on actual determinations and calculations.

I. Introduction

In the electric annealing of glass, some of the principal points for discussion are (1) annealing, (2) arrangement, distribution, and control of the heat, (3) some details of leer design affected by electric heat, (4) calculation of heat requirements, and (5) description of the electrical equipment involved.

II. Annealing Requirements

(1) Temperature Gradient

The annealing of glass consists in heating to a temperature at which stresses will be relieved quickly, and then cooling uniformly. The cooling portion of the cycle begins without any appreciable temperature gradient or stress

* Presented at the Annual Meeting, AMERICAN CERAMIC SOCIETY, Washington, D. C., February, 1932 (Glass Division). Received January 29, 1932.

in the glass. Upon cooling, a temperature gradient in each piece of glass is established, the gradient depending on the thickness of glass and the rate and method of cooling. This temperature gradient produces a proportional stress which is relieved only when the gradient is removed. This may occur at any portion of the cycle or at room temperature as desired.

(2) Rate of Heating and Cooling Whether or not a piece of glass will be given the anneal required depends upon the condition of the glass at the beginning of the cooling cycle and the rate and uniformity of cooling.

If the proper temperature curve can be secured and held constant, the time may be considerably less than under the conditions where this proper curve can not be secured or controlled.

(3) Heat Required To calculate the heat required to anneal a given type of glassware it is necessary to know the time-temperature curve and all the details that affect the heating and cooling. Such details are as follows: (*a*) average entering temperature of the glass, (*b*) type of ware and weight of glass to be annealed per hour, (*c*) type, weight, and speed of conveyer, and (*d*) leer construction, including insulation, method of loading, inside width, height and length, method of cooling, etc.

The specific heat of glass (B.t.u. required to raise one pound of glass one degree Fahrenheit) varies with the temperature and type of glass. For average conditions the specific heat of 0.22 may be used.

If it is assumed that 1000 pounds of glass per hour enter the leer with an average temperature of 700°F to be heated to 1000°F, then the B.t.u. required are $1000 \times 0.22 \times (1000-700) = 66{,}000$ B.t.u. One kilowatt-hour contains 3412 B.t.u.; therefore $66{,}000/3412 = 19.3$ kw.-hr. required to raise 1000 pounds of glass 300°F.

For the majority of ware, such as bottle glass, the average entering temperature can be such as to require little or no further heating of the glass. In fact, in many cases the average temperature of the glass on entering may be higher than the required annealing temperature, thereby furnishing the heat required to compensate the heat losses from that portion of the leer where the temperature is to be held constant and supplying part or all of the heat required for the conveyer. It is from this latter condition that the term "heatless leer" was obtained.

(4) Effect of Ware Size The shape of the ware affects the loading per foot of conveyer and also the time required to bring the glass to a uniform temperature. The loading rate or production of pounds of glass per hour affects the power required to heat the glass; it also affects the cooling rate.

(5) The Conveyer The conveyer is the most important part of the leer. It should be light in weight and open in construction. The type used in the jitney leer is the mesh-belt conveyer made of spirally wound wire and alternate weave. Such a conveyer is light in weight (2 to 4 pounds per square foot, depending on the conditions to be met), and is open in construction.

The effect of the conveyer on the heat required is as follows:

Assuming a conveyer 48 inches wide; weight, 3 pounds per square foot or 12 pounds per running foot; speed, 9 inches per minute; entering temperature, 100°F; annealing temperature, 1000°C: Then, $9/12 \times 60 \times 12 = 540$ pounds of conveyer to be heated per hour. The average specific heat of steel at 1000°F is 0.135. Therefore $\frac{540 \times 0.135 \times (1000-100)}{3412} =$ 19.2 kw.-hr. required to heat the conveyer.

If this conveyer is preheated to 700°F outside of the heating chamber by some means other than electric heat, then the heat required in the heating chamber for the conveyer is 6.4 kw.-hr.

NOTE: Where gas is available at low rates, it is practical and economical to preheat the conveyer with gas. In this case all preheating must be done outside of the annealing chamber.

In some cases it may be practical to return the conveyer inside of the leer so that the conveyer is preheated by the outgoing hot glass.

(6) Leer Construction The leer must be properly insulated. The thickness of insulation for the heated portion of the leer should be equivalent to 8 to 10 inches of high-grade insulating material. The leer should be inclosed in a sheet-steel casing so as to prevent air infiltration through the walls.

(7) Insulation As a general rule the heat loss (at chamber temperature of 1000°F) through 9 inches of high-grade insulation is approximately 0.06 kw.-hr. per hour per square foot of inside area. This figure, for all practical purposes, will vary directly with the temperature for the temperatures involved in glass annealing.

Therefore, for a 48-inch wide conveyer leer, having inside wall-to-wall width of 52 inches and a total height, floor to floor, of 24 inches and 9 inches of insulation, the heat loss through the walls for a chamber 5 feet long at 1000°F will be approximately 3.75 kw.-hr. per hour.

(8) Inside Dimensions The inside dimensions of the leer should be such that the distance from a side wall to the glass is about 2 to 3 inches. The height from conveyer to roof need be only sufficient to take care of the higher ware plus about 2 inches, except where top heating units are used; then space allowance must be made for the units. Below the conveyer a space of from 6 to 8 inches, depending upon the construction of the leer, is required for the bottom heating units.

III. Power Consumption

An example of the calculation of power consumption in the following assumed conditions is presented:

(*a*) Leer with 48-inch wide conveyer weighing 12 lb. per running foot
(*b*) Inside wall-to-wall dimensions, 52 inches wide, 24 inches high, and length of heated section, 15 feet
(*c*) Conveyer speed, 9 inches per minute
(*d*) Entering temperature of conveyer, 700°F
(*e*) Entering temperature of glass, 1100°F
(*f*) Production, 1000 pounds of glass per hour
(*g*) Annealing temperature, 1000°F
(*h*) Temperature curve in heated portion, first 10 feet held at 1000°F; next 5 feet held at 970°F

From the above calculations it is found that

	(kw.-hr.)
Heat required by conveyer	6.4
Heat loss for 15-ft. heating chamber	11.3
Total heat required	17.7

(1) Glass Entering at 1100°F Excess temperature in entering glass is 1100°F − 1000°F = 100°F. Therefore, $\frac{1000 \text{ lb.} \times 0.22 \times 100}{3412} = 6.5$ kw.-hr.

In the 5-foot section where the glass cools from 1000°F to 970°F (30°), the heat given up by the glass in cooling is $\frac{1000 \times 0.22 \times 0.30}{3412} = 2$ kw.-hr. The heat given up by the conveyer in cooling 30°F is $\frac{540 \text{lb.} \times 0.135 \times 30}{3412} =$ 0.6 kw.-hr.

The total heat given up by the glass and conveyer in the heated section equals 6.5 + 2 + 0.6 = 9.1 kw.-hr.

Therefore 17.7−9.1 = 8.6 kw.-hr. = total heat to be supplied by the heating units.

The economy or pounds of glass annealed per kilowatt-hour equals 1000/8.6 = 116.

(2) Glass Entering at 900°F If the average entering temperature of the glass is 900°F instead of 1100°F and all other conditions the same as given above the following calculations are made:

	(kw.-hr.)
Heat required by conveyer	6.4
Heat loss for long heating chamber (15 feet)	11.3
Heat required to raise 1000 lb. glass 100°F	6.5
Total heat required	24.2
Heat given up by glass and conveyer on cooling 30°F	2.6
Total heat to be supplied by heating units	21.6

Economy 1000/21.6 = 46 lb. glass annealed per kw.-hr.

(3) Effect of Entering Temperature and Pounds of Glass

Figures 1 and 2 show the calculated pounds of glass annealed per kilowatt-hour under various conditions.

Table I shows actual operating results from two installations. The first part of this table shows an average economy for five months' operation of 57.5 pounds of glass annealed per kilowatt-hour. This average figure includes all shut downs, power to heat up leers, etc.

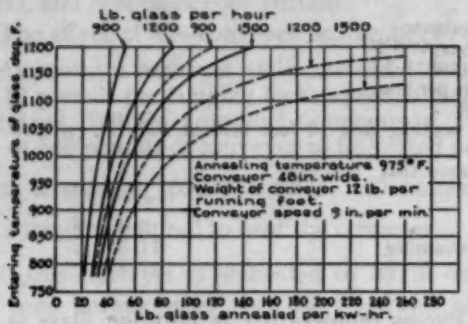

FIG. 1.—Solid lines show area where conveyer is not preheated. Dotted lines show area preheated to 600°F outside of the electrically heated chamber.

In data from another installation (second part of Table I), the power consumption figures do not at first appear to be consistent. The power consumption for the milk bottles, for instance, seems too high as compared with the other types of ware.

Normally the power consumption when annealing milk bottles should be lower, giving an economy of over 100 pounds of glass annealed per kilowatt-hour. Either the production in pounds of glass or the average entering temperature was below normal in the case of the milk bottles.

IV. Location of Heating Units

Since the usual dimensions of a leer are such that the width is greater than the height, and there is only one layer deep and many rows wide, the logical location of the heating units is above and below the ware. As seen from the calculation of heat requirements, the heat required by the glass is usually a small portion of the total heat required, the conveyer and wall loss requiring the majority of the heat.

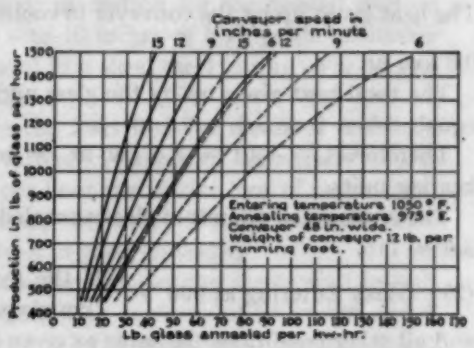

FIG. 2.—Solid lines show area where conveyer is not preheated. Dotted lines show area preheated to 600°F outside of the electrically heated chamber.

For temperatures of approximately 1000°F and below, the major portion of the heat will be supplied by convection.

TABLE I. OPERATING RESULTS FOR FIVE CONSECUTIVE MONTHS IN A PLANT HAVING 13 ELECTRIC LEERS IN OPERATION

Month	No. 1	No. 2	No. 3	No. 4	No. 5	Av. for 5 mo.
Working days/month	23	28	23	25	27	25.2
Av. number of leers/day	9	8.6	8	12	13	10.2
Total leer days operated/month	207	240	184	300	351	257
Kw.-hr./month	80,230	93,690	66,862	115,550	113,230	93,910
Kw.-hr./leer day	387	390	364	385	322	370
Total tons glass/month					3,800	2,700
Pounds glass/kw.-hr. average					67.2	57.5

OPERATING RESULTS FOR VARIOUS TYPES OF WARE

Capacity (oz.)	Type of ware	Weight (oz.)	Kw.-hr./ gross	Lb. of glass/ kw.-hr.	Cost of power/ gross at 1 cent/kw.-hr.
14	Ovals	11 7/8	2.67	40	$0.0267
16 1/4	Mayonnaise jars	11 1/4	1.97	52	0.0197
32	Milk bottles	27 1/4	4.19	59	0.0419
36	Jars	22	2.86	69	0.0286
32	Mayonnaise jars	20 1/4	2.54	72	0.0254
16	Mayonnaise jars	12	1.29	84	0.0129
32	Packer jars	19 1/2	1.37	128	0.0137
9	Soda bottles	16	1.10	131	0.0110

For these reasons heating units are placed below the conveyer throughout the heating chamber. In most cases it is desirable to have some heat in the top of the leer for the first few feet.

The top heating units in the first zone may be grouped with the bottom heating units of the first zone and both controlled from one temperature control, or the top and bottom units of this first zone may be controlled

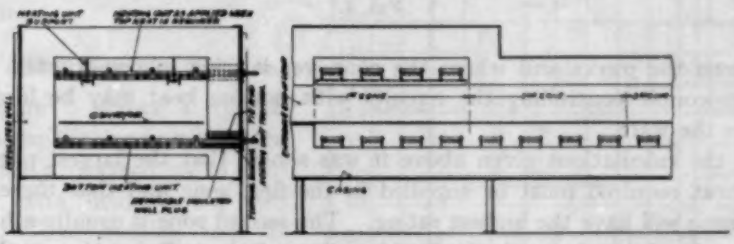

FIG. 3.—Mounting, location, and connection of heating units in typical electric glass annealing leer.

separately, depending on the conditions. Usually separate controls should be used as this gives the maximum flexibility.

The amount of heat required in the top varies with the type of ware, entering temperature, production, and conveyer speed. Controlling the top units separately, varying conditions are taken care of automatically.

In all heating units the resistor should be so distributed as to concentrate extra heat at the sides of the leer to compensate for side-wall heat losses. This is readily accomplished with the metallic resistor.

V. Leer Zones

The usual time-temperature curve requires a heating chamber from 15 to 20 feet long, divided into sections or zones approximately 5 feet long.

A typical layout of the zones and heating units is shown in Figs. 3 and 4. A heating chamber divided into four zones in the length, with heating units in the bottom of all zones and only the top for the first zone, is shown.

Each zone should have an independent temperature control and in most cases the top and bottom units in the first zone should be on separate controls. This gives a total of five independent controls or circuits for a four-zone layer.

VI. Temperature Control

The temperature for each circuit is automatically controlled by means of a thermocouple and suitable temperature-control equipment.

The logical location of a control thermocouple is between the heating units and the material being heated. In a glass leer where there is space

FIG. 4.

between the pieces and where the conveyer is open in construction the thermocouple controlling the circuits with bottom heat may be located above the ware.

In the calculations given above it was shown that the largest part of the heat required must be supplied in the first zone and that therefore this zone will have the highest rating. The second zone is usually a holding zone and therefore only the heat loss through the walls is to be supplied. In the remaining zone or zones which are usually cooling zones, the only heat required is the difference between the wall losses and the heat given up by glass and conveyer in cooling.

A typical conveyer jitney leer 48 inches wide will have a total rating of approximately 60 to 90 kw.-hr. For a four-zone heating chamber approximately 20 feet long, the first zone will be rated 30 to 45 kilowatts (about one-third of this in the top) and the remaining divided about equally between the other zones.

Such a rating is much higher than that required for continuous full-load operation, but the total kilowatt rating and division of this power

must be such as to take care of all the conditions properly that are to be met with in service.

The electric heating and control equipment for a leer, such as the so-called jitney leer, is not at all complicated. This equipment consists of

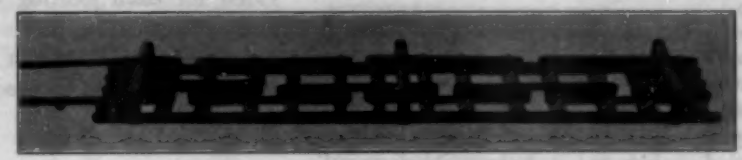

FIG. 5.—7.5 Kilowatt, 55-volt heating unit for 48-inch glass leer.

standard control devices and heating units of standardized design. While the equipment is not complicated, it must be correctly designed and applied if the full advantage of electric heat is to be obtained.

With the metallic resistor, the electric heating units can be located as desired and in each heating unit the resistor may be distributed as desired.

With such flexibility of heat source and control, and with knowledge of the conditions to be met, the correct heat distribution may readily be obtained.

VII. Heating Unit

Figure 5 shows a typical glass leer heating unit with the resistor so formed as to provide extra heat at the two ends. The heating unit is placed cross-wise of the leer, and therefore this extra heat at the two ends provides the necessary extra heat at the sides of the leer.

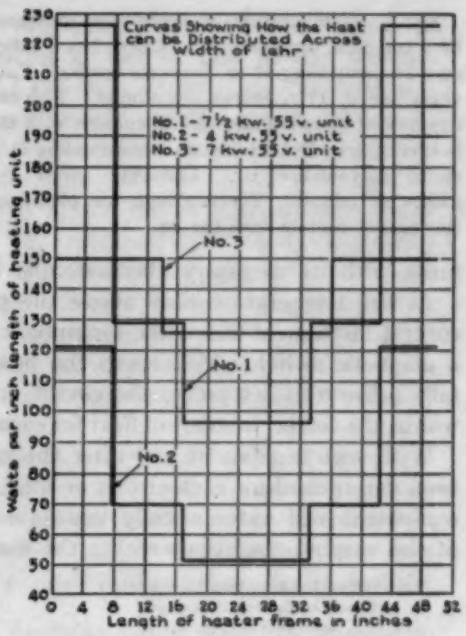

FIG. 6.

The curves in Fig. 6 show the flexibility in design of such a unit in the distribution of the heat in its length.

The units are arranged so that any unit may be inserted or removed through a side wall of the leer. The removable heating unit permits repair or replacement in case of accident without seriously interfering

with production, as a unit may readily be replaced while the leer is in operation.

The leer outline in Fig. 4 shows a typical mounting of the units and their arrangement in the leer. An insulated removable wall plug is provided for each heating unit and the heating-unit terminals extend through refractory bushings located in this wall plug.

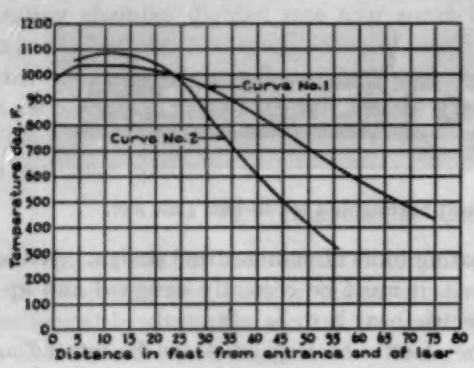

FIG. 7.—Temperatures in electric leer measured by a traveling thermocouple. Curve No. 1 taken on a leer annealing 14-oz. beverage bottles. Conveyer speed, 11¼ inches per minute. Thermocouple was placed under and in contact with the bottle. Curve No. 2 taken on leer annealing 7⅜-ounce mayonnaise jar. Conveyer speed 4½ inches per minute. Thermocouple was placed inside and in contact with the jar.

VIII. Time-Temperature Curve

Figure 7 shows the time-temperature curves for two electrically heated leers. The temperature readings were taken by means of a traveling thermocouple in contact with the glass.

The temperature-control equipment for each circuit consists of a standard automatic control panel and a temperature-control instrument with its necessary thermocouple and connections.

As the temperature rises above the point at which the temperature-control instrument is set, the instrument through a control relay operates a magnetic switch which opens the power circuit. As the temperature falls below this set point, the circuit is automatically closed. In other words, the correct amount of heat for each circuit is automatically supplied.

With such equipment and after the correct temperature settings have been determined for each circuit or zone, no attendance is required. The equipment will automatically maintain the set temperatures regardless of the varying conditions within the maximum rating of the equipment.

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APPLICATION OF GARDNER MOBILOMETER TO ENAMEL SLIP CONSISTENCY STUDIES AND CONTROLS*

By G. H. McIntyre and J. T. Irwin

ABSTRACT

A brief review of the type of instrument used by previous investigators is given. The Gardner mobilometer is described and its application to enamel-slip consistency problems and control is discussed.

I. Introduction

The instruments used by previous investigators[1] in demonstrating the plastic properties of clay slips alone or with additions of powdered quartz and feldspar and of enamel slips were modifications of the apparatus used by E. C. Bingham.[2]

These investigators have shown that clay slips, with or without additions of powdered quartz or feldspar, and enamel slips have plastic properties and that their physical condition may best be described in terms of "yield-value" and "mobility."

Since enamel slips possess plastic properties it is insufficient to describe their "set-up" or consistency in terms of rate of flow at one pressure through a standard size opening, or the time required for the flow of a definite volume or weight through a standard opening. Any instrument depending on either of these factors to determine "set-up" or consistency of enamel slips is wrong in principle.

Several difficulties are encountered in the use of consistometer tubes as described for plant control work. It is difficult to duplicate tubes since slight variations in the length and diameter of the capillary tube have a great effect on the relative consistency curves. (Curves were produced by plotting the pressure in centimeters height and the rate of flow in cubic centimeters per second.) Calculation of all determinations to absolute units is not feasible for plant control, although it may be done in laboratory investigations.

The Institute of Paint and Varnish Research has developed an instrument known as the "Gardner mobilometer,"[3] which possesses certain advantages over the consistometer tube. While there are published reports covering the use of the mobilometer in several fields, there does not seem to be any reference to its use in laboratory investigations of the

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* Presented at the Annual Meeting, American Ceramic Society, Washington, D. C., February, 1932 (Enamel Division).

[1] (*a*) R. E. Wilson and F. P. Hall, "The Measurement of Plasticity of Clay Slips," *Jour. Amer. Ceram. Soc.*, 5 [12], 916 (1922).

(*b*) R. D. Cooke, "Plastic Properties of Enamel Slips," *ibid.*, 7 [4], 651 (1924).

(*c*) W. N. Harrison, "Controlling Consistency of Enamel Slips," U. S. Bur. Stand., *Tech. Paper*, No. 356.

[2] U. S. Bur. Stand., *Sci. Paper*, No. 278.

[3] Scientific Section Educational Bureau of American Paint and Varnish Manufacturers' Assn., *Circular*, No. 394, p. 317, October (1931).

mechanics and principles involved in "setting-up" enamel slips or in plant control of enamel consistency. It is the purpose of this paper to demonstrate the adaptability of the Gardner mobilometer to laboratory investigations of enamel "set-up" problems and to plant control.

II. Gardner Mobilometer

The instrument consists essentially of a cylinder supported by a base plate, a plunger or piston, and a bracket to support the plunger. The plunger consists of a disk with 51 perforations $^1/_{16}$ inch (1.59 mm.) in diameter, and a weight pan attached to opposite ends of a brass tube. Two supplementary disks, which greatly extend the range of the instrument, are supplied. One is solid, the other has four holes 6.25 millimeters in diameter. (See Fig. 1.)

The weight of the moving system, which includes the disk, connecting tube, weight pan, and lead shot in the hollow connecting tube is 100 grams.

FIG. 1.—Gardner mobilometer.

The cylinder is filled to a depth of 20 centimeters with the material to be tested. The cylinder is leveled by means of the adjusting screws. The disk end of the plunger is then introduced into the cylinder and the bracket attached. The time required for two marks, 10 centimeters, or any other convenient distance apart, on the stem of the plunger to pass through the collar is then recorded. The marks on the cylinder were chosen at two points which represented the passage of the piston head through 150 cubic centimeters of the sample. In plotting the results, the rate of flow (of the sample through the openings and around the circumference of the piston-head disk) in cubic centimeters per second has been plotted against the total applied pressure and an average straight line drawn through these points and the pressure axis.

In general, these points fall very close to an average straight line drawn through them and quite often they fall directly on such a line. The intersection of the consistency line with the pressure axis gives the yield-value in grams-pressure required to start flow.

NOTE: A certificate may be secured with each mobilometer giving the relation between that instrument and the Master Reference Mobilometer kept at the Institute of Paint and Varnish Research, Washington, D. C. This makes it possible to compare results obtained on different mobilometers merely by multiplying the time by the factor.

Consistency graphs of enamel slips plotted from data obtained with a mobilometer are similar to those obtained from consistometer tube data. The units are relative and not absolute, but relative yield-values and mobilities are indicated.

(1) Enamel Slips Studied

During the course of investigation on the effects of (1) potassium chloride, (2) boric acid, (3) mixtures of potassium chloride and boric acid, (4) clay content, and (5) water content on the consistency of an experimental enamel, this laboratory used the Gardner mobilometer to follow changes in the consistency of the enamel slip.

A series of millings was made in which the concentration of potassium chloride was varied from zero to the equivalent of one part potassium chloride per 100 parts of frit. The clay and water content were kept constant and the millings were ground to the same degree of fineness. Consistency determinations were made on these millings with the Gardner mobilometer 24 hours after milling and also after aging 25 days. The results of these determinations are shown in Fig. 2. The solid lines represent the consistency after 24 hours and the dotted lines, the consistency after 25 days.

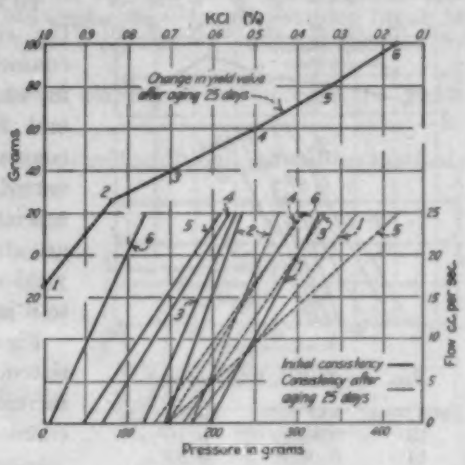

FIG. 2.—KCl series.*

Mill No.	KCl (%)	Mill No.	KCl (%)
1	1.00	4	0.50
2	0.83⅓	5	0.33⅓
3	0.66⅔	6	0.16⅔

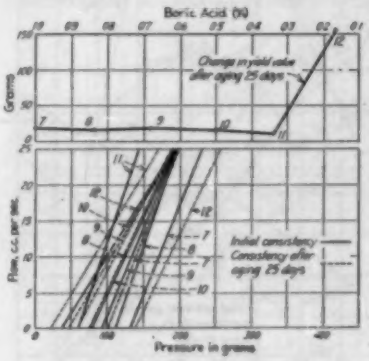

FIG. 3.—Boric acid series.*

Mill No.	Boric acid (%)	Mill No.	Boric acid (%)
7	1.00	10	0.50
8	0.83⅓	11	0.33⅓
9	0.66⅔	12	0.16⅔

Figures 3 and 4 represent the results of similar tests of millings in which the boric acid content and potassium chloride-boric acid ratios were varied.

The curves showing the yield-values plotted against the concentration appear in Fig. 5. A study of these curves will indicate the correct mill additions to use with this particular frit to produce any desired yield-value within their range, and the

* EDITOR'S NOTE: The per cent content of KCl, B_2O_3, and H_2BO_3 : KCl (Figs. 2, 3, and 4) are in tenths. The draftsman's decimal points after the ciphers are lost in the size reduction.

change in consistency that may be expected after the enamel has aged 25 days.

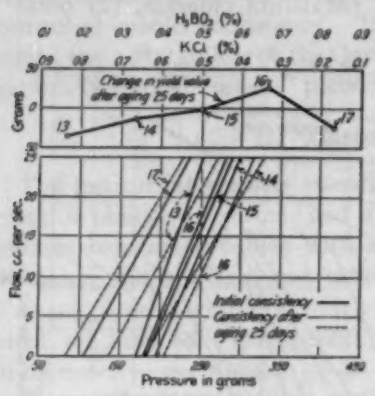

FIG. 4.—H_3BO_3:KCl series.*

Mill No.	KCl (%)	H_3BO_3 (%)
13	0.83⅓	0.16⅔
14	0.66⅔	0.33⅓
15	0.50	0.50
16	0.33⅓	0.66⅔
17	0.16⅔	0.83⅓

To determine the effect of clay on the consistency of an experimental enamel, a series of millings was made in which the frit, water, tin oxide, and fineness of grinding were kept constant while the clay content was varied from 3 to 10%. The consistencies of these millings after 24 hours are shown in Fig. 6. The change in yield-value with change in clay content is also shown in Fig. 6.

Figure 7 shows a set of typical consistency curves obtained by gradually increasing the water content of an enamel slip.

III. Properties of Enamel Slips

The conclusions drawn apply only to the particular frit under investigation. Other factors remaining constant are as follows:

(1) Change in yield-value is directly proportional to the change in concentration of potassium chloride.

(2) Yield-value gradually approaches a value of approximately 150 regardless of the concentration of potassium chloride.

(3) As the boric acid concentration is increased, the initial yield value increases proportionately.

(4) Aging tends to decrease the yield-value for any given concentration of boric acid, the amount of decrease remaining fairly constant up to 0.83% boric acid beyond which point there is an increase in yield-value with aging.

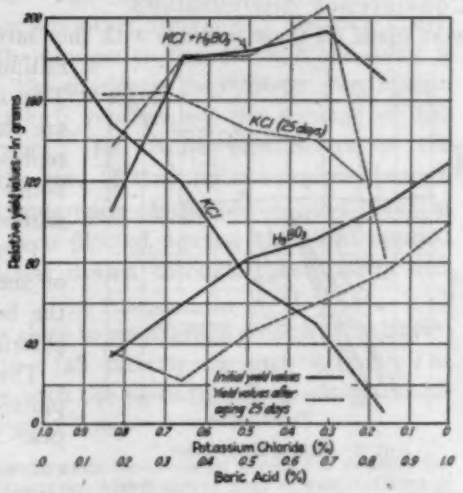

FIG. 5.—KCl, H_3BO_3, and KCl:H_3BO_3 series.

(5) Potassium chloride and boric acid mixtures cause a rapid increase in initial yield-value as the boric acid portion of the mixture is increased

* See note p. 435.

from 0 to 50%. Aging of a slip with this combination of salts shows less effect on yield-value than the other combinations studied.

(6) The effect of clay content on initial yield-value is not pronounced, except when 7% clay is used. No explanation for this sudden break in the curve can be offered at this time. This effect has been checked by duplicate millings.

(7) The effect of increased water content is to decrease the yield-value and increase the mobility.

In the same way, the effects of various mill additions and milling methods on other experimental enamels can be studied. These will vary with the composition of the enamel frits being used, due probably to the nature and amounts of salts dissolved from the frit during grinding and aging.

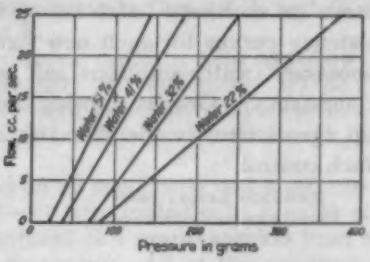

FIG. 6.—Typical set of consistency graphs showing the effect of water additions on consistency of enamel slips.

IV. Method for Determining Effect of Mill Additions

One problem of this type was the determination of the proper mill additions to use with an experimental enamel in order to get the same average consistency as was obtained with a commercial enamel in a production shop.

Mobilometer determinations were made on successive millings of the commercial enamel for several days, and an average consistency curve determined. A consistency determination was made on a milling of the experimental enamel and the consistency curve compared with that of the commercial enamel. The experimental enamel showed a lower yield-value and higher mobility than the commercial enamel.

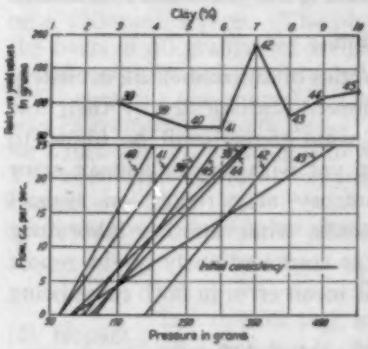

FIG. 7.—Clay series.

Mill No.	Clay (%)	Mill No.	Clay (%)
45	3	41	7
44	4	40	8
43	5	39	9
42	6	38	10

Magnesium sulphate was added as a mill addition to several successive mills until one showed the desired yield-value. At this point the mobility was too high, so small amounts of deflocculating materials were added until the mobility was as desired. In the meantime the yield-value had reached a lower figure, and the "salts" content had to be increased.

By studying the mobilometer curves of each successive milling it was

possible to follow the exact effect of each change made, and eventually to determine in a shorter time than would have been possible without some such aid, the exact mill additions required with the experimental enamel to produce a slip of the same consistency as the commercial slip.

The rugged character of the apparatus and the uniformity of results obtained with different mobilometers commend it for use as a plant control instrument. For such work, standard consistency curves can be determined for each type of slip being used in the shop, and determinations made on each new batch before use in production. A study of the consistency curves for such new batches will show what treatment may be necessary (water additions, salt additions, etc.) to bring it to the standard consistency. Graphs showing the effect of water, and of different setting-up agents used in the shop on the various frits would be another aid in such control.

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FACTORS CAUSING THE VARIATION OF RESULTS IN TESTS FOR THE PHYSICAL PROPERTIES OF ENAMELS*

By E. H. Shands, R. H. Turk, and H. G. Wolfram

ABSTRACT

The reason for variability of tests for physical properties of porcelain enamel was investigated. Conclusions are drawn from over 1200 tests on 700 specimens. Slight differences in gage of base metal, its source and method of manufacture, and the fineness and thickness of the enamel coating and firing temperature all seriously affect the results obtained. These physical properties may be adjusted at will by regulating the method of preparation.

I. Introduction

In a laboratory where the physical properties of an enamel are definitely controlled, the reliability of the tests is proved statistically by their low mean error. In another laboratory this same enamel will be found to have entirely different physical properties, yet with as small mean error in test results. For instance, one laboratory may report an enamel with an impact resistance of 1.2 foot-pounds, while another laboratory with a similar machine and working just as conscientiously might report an impact resistance of 1.8 foot-pounds, the mean error in both cases being almost the same.

This investigation was made to determine what differences in preparation of the specimens might cause these variations in results. The effect of fineness of grinding, firing temperature, thickness of coating, gage of base metal, and type and source of base metal were investigated. The comparisons drawn are based on more than 1200 tests on over 700 specimens run under standard laboratory conditions.

* Presented at the Annual Meeting, American Ceramic Society, Washington, D. C., February, 1932 (Enamel Division).

II. Procedure

(1) Base Metal Specimens Plates 4 by 6 inches were prepared for the impact test from seven brands of 20-gage enameling stock, both regular and deep drawing. Strips 2 by 12 inches were prepared for the deflection and thermal shock tests, also from the above-mentioned plates. Like specimens were prepared in 16, 18, 20, 22, and 24 gages from one of the above enameling stocks. For thermal shock, a deflection strip was divided in six equal parts giving 2- by 2-inch samples. Metals A, B, C, D, and F are ordinary enameling stocks. Metal E is deep-drawing stock of the same manufacture as D, and G is deep-drawing of the same manufacture as F.

(2) Pickling All base metal was pickled using muriatic acid as follows: (*a*) boiling commercial cleaner, (*b*) hot rinse, (*c*) 33% solution of commercial muriatic acid, (*d*) cold rinse, (*e*) cold soda solution (1 lb. soda ash to 60 gal. water), (*f*) boiling borax solution (1 lb. borax to 30 gal. water).

(3) Ground Coat The ground coat used on all specimens was a mixture of half-hard and half-soft frits milled with 8 parts of Vallendar clay and $^1/_2$ part borax to a fineness of 4 grams residue from a 50-cubic centimeter sample on a 150-mesh screen. All of the specimens for the impact tests were dipped at the equivalent of 68 grams dry per 2 square feet and fired at 1575°F for $2^3/_4$ minutes. The deflection and thermal shock strips were sprayed at the same weight and fired at the same temperature. The firing time was increased on heavier gages. The average linear coefficient of expansion of this ground coat was 12.07×10^{-6} (50–450°C). Incipient melting point was 530°C.

(4) Cover Coats The cover-coat enamel was a commercial sheet-iron white, milled with 7 parts Vallendar clay and 4 parts tin oxide to a fineness of 2 grams residue from a 50-cubic centimeter sample on a 150-mesh screen. The plates and strips were given 2 cover coats on the basis of 50 grams wet weight per square foot each on one side. The specific gravity was maintained at 1.87 to permit the use of wet weight when spraying the enamel. The total fired weight of the two cover coats was 72 grams per square foot. The cover-coat enamel was fired at 1500°F for 2 minutes. The firing time was increased slightly on the heavier gages. The coefficient of linear expansion for the range of 50 to 450°C of this enamel was 11.69×10^{-6} with an incipient melting point of 507°C. All specimens were fired in an electric furnace.

III. Tests

(1) Impact The impact test was conducted on the machine which has been previously described.[1] The specimen was so tightly held that the metal was upset very little during the test and there was practically no vibration when the hammer struck it. As every effort was made to produce a flat specimen, no twisting was evident when the clamps were drawn up. The impact test consisted of a flexing blow and a crushing blow.

[1] R. H. Turk, "A Comparison of Results Obtained with an Impact Machine," *Jour. Amer. Ceram. Soc.*, **13** [11], 887–93 (1930).

In the flexing blow, the enamel being tested faced in the opposite direction from the hammer, the hammer striking the back of the plate. The first blow given was 0.05 foot-pound. The intensity of the impact was increased by increments of 0.05 foot-pound until the enamel chipped. This was recorded as initial failure and was somewhat variable. The intensity of the impact was further increased by like increments until the enamel chipped from the specimen over an area of approximately 1/4 inch in diameter. This result was recorded as failure and was fairly consistent.

In the crushing blow test, the hammer struck the enamel under test directly. Otherwise, the procedure was the same as for flexing blow. No initial failure was recorded.

(2) Deflection Deflection tests were made in accordance with the Tentative Method of Determining the Resistance of Sheet Iron Enamels to Deflection on a standard deflection machine.[2]

(3) Thermal Shock The thermal shock test was conducted on an apparatus the principle of which was suggested by C. J. Kinzie.[3] It consisted essentially of a heat source upon which the specimen to be tested was placed, and a capillary tube which allowed water to drop on the specimen at a uniform rate. This test was conducted by placing a 2- by 2-inch specimen to be tested on the heating source and allowing it to heat up to a temperature of 680°F. When the temperature reached this point, water was allowed to drop at the rate of approximately three drops per minute for thirty minutes. At this time the specimen was removed, allowed to cool, and a mixture of black oxide and oil rubbed over the surface. The resistance to thermal shock was determined by the intensity of crazes in the area where the water was allowed to drop. As no method was known for measuring the degree of failure, the results were classified as (*a*) no visible failure, (*b*) very faint craze lines, (*c*) distinct deep crazes, and (*d*) chipping.

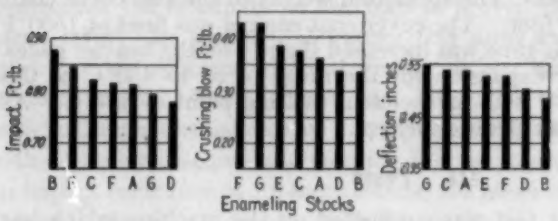

FIG. 1.—Effect of different brands of enameling stock on impact and deflection resistance.

IV. Effect of Different Brands of Metal

It was found that widely varying results were obtained when different brands of base metal were used. The base metal had a quite serious effect upon all physical properties with the exception of thermal shock.

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[2] R. R. Danielson and W. C. Lindemann, "Method for Testing Cross-Bending Strength of Enamels," *Jour. Amer. Ceram. Soc.*, **8** [12], 795 (1925).

[3] "Physical Tests for Vitreous Enamels," *ibid.*, **12** [3], 188 (1929).

In Fig. 1, the results for deflection and impact on various metals are graphically shown.

In spite of the fact that about 500 tests were made, sufficient work has not been done to establish any relation between different brands of metal and the results of physical tests.

(1) Deep-Drawing Stock Several lots of deep-drawing stock were tested with much the same results. The variables were so great that it was not possible to establish any relation between the quality of the stock and the physical properties of the enamel applied thereon.

V. Effect of Gage

The gage of base metal has quite an effect upon the resistance to physical shock of porcelain enamel (see Fig. 2). On the lightest gage metal the deflection resistance was quite high, decreasing as the thickness of the metal increased. In making the deflection tests, the point where the initial crack appeared was noted as initial failure. This was plotted along with the final failure. It is interesting to note that as the thickness of the metal increased, the amount of deflection required to bring about total failure, after initial failure had appeared, became constantly less until at 16-gage the first crack immediately went straight across the specimen. This indicated that deflection failure was to be expected sooner in heavier gages of metal and that it will be much more severe than in lighter gages.

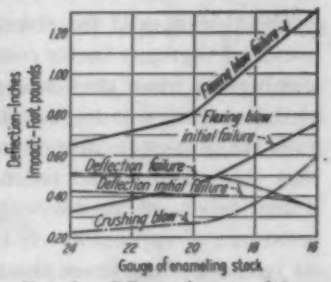

FIG. 2.—Effect of gage of base metal on impact and deflection resistance.

The impact resistance of the enamel increased greatly as the thickness of the metal was increased. The impact resistance was about twice as great on 16-gage metal as on 24-gage metal. The ratio between initial and final failure in impact was practically constant throughout the test. Crushing-blow impact tests also became higher as base metal increased in thickness.

It is interesting that there is apparently a critical point in these curves at about 20-gage metal. Each curve is symmetrical but breaks at this point and projects along an entirely different slope. As it is desirable to test all materials at about their critical point, this indicates that an ideal thickness of metal for testing enamels is 20-gage.

VI. Effect of Fineness of Grinding

Small differences in the fineness of the enamel seriously affected the impact resistance. From a fineness of 1 to 3 grams, the impact resistance

to flexing blow was steadily lowered. From 3 to 8 grams, the impact resistance to flexing blow increased. This series of finenesses represents the limits in which commercial enamels are used today. Fineness affects impact resistance to crushing blow in an almost directly opposite manner. This is best shown by the curves in Fig. 3.

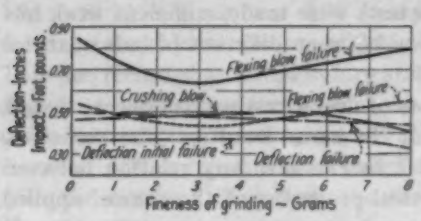

FIG. 3.—Effect of fineness of grinding on impact and deflection resistance.

Resistance to deflection was lowered with decreased fineness at a constant rate. At a fineness of one gram the resistance was 0.49 and lowered to 0.44 when the fineness was at 8 grams.

VII. Thickness of Coating

The thickness of the enamel coating had greater effect upon the results obtained than any factor considered. The impact resistance of the enamel was highest when the coating was thin and rapidly fell off as the thickness of the coating was increased. At approximately 36 grams to one square foot, the impact resistance to flexing blow was one foot-pound. At double that thickness, it had fallen off 25%, and at three times the thickness, it had fallen off approximately 35%. The enamel had a crushing-blow resistance of approximately 0.8 foot-pound at 36 grams to one square foot. At twice that thickness this resistance had decreased approximately 40%; the crushing resistance, however, slowly increased from this point and at three times the original thickness the resistance was approximately 65% of the original strength.

It is interesting to note that the impact resistance to flexing blow also showed a tendency to increase when the thickness of the enamel became great, though sufficient tests were not made at this end of the curve to establish this definitely as a fact.

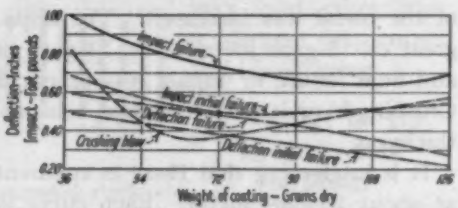

FIG. 4.—Effect of thickness of coating on impact and deflection resistance.

The deflection resistance of the enamel speedily decreased as the thickness of the coating increased. The line representing deflection failure was almost perfectly straight indicating that the deflection resistance is a true function of the thickness of the enamel. Stated otherwise, the deflection resistance was approximately inversely proportional to the thickness of the enamel.

An increase of 7.5 grams of enamel to the square foot was sufficient to

lower the deflection resistance 0.02 inch. This can best be shown by curves in Fig. 4.

VIII. Effect of Firing Temperature

The temperature at which an enamel is fired has no great effect upon any of its physical properties except impact resistance to crushing blow. In this particular test, the impact resistance was the lowest at what is likely the normal firing temperature of the enamel being tested. When the enamel was underfired, the impact resistance to crushing blow was high and as the temperature exceeded normal, the resistance again increased.

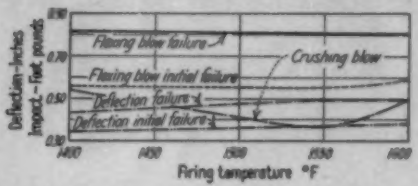

FIG. 5.—Effect of firing temperature on impact and deflection resistance.

The impact resistance to flexing blow produced an almost straight horizontal line.

The resistance to deflection was slowly increased with increased temperature until the normal firing temperature was approached, then the deflection resistance became constant. The curves in Fig. 5 show these results.

IX. Thermal Shock

In all the tests made, thermal shock was not noticeably affected except when the thickness of the enamel became excessive, that is, beyond all practical limits. Normally, failure on the thermal shock resulted in a series of craze lines but when the enamel was very thick it chipped away in large pieces from the ground coat.

X. Conclusions

(1) The base metal must be uniform and of the same manufacture and quality.

(2) The gage of the metal must be absolutely uniform.

(3) The fineness of the enamel as applied must be standardized.

(4) Very slight differences in the thickness of coating of the enamel will give radical differences in results. Increased thickness of coating causes low impact and deflection resistance.

(5) Firing temperature has little effect upon impact resistance to flexing blow and deflection resistance. Crushing-blow strength is high in under- and over-fired enamels, and is lowest at normal firing.

(6) Thermal shock is not affected by variations in the preparation of specimens except when the thickness of enamel is greater than the normal practice.

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THE IMPORTANCE OF ACCURATE SAMPLING IN THE PRODUCTION AND USE OF CERAMIC MATERIALS*

By F. P. Knight, Jr.

ABSTRACT

A discussion of the theory and methods of sampling and their application to the production and use of feldspar and other ceramic materials is presented. Analytical data concerning segregation within shipments and bin contents are given.

I. Introduction

Sampling is the process of selecting a representative portion of a lot of material. An accurate sample is one in which all of the components are present in the same proportions and states as they occur in the original lot.

The importance of correct sampling is too often disregarded and too often carelessly done. It is much easier to take a handful from a bin of ground feldspar than it is to take portions systematically from all sections of the bin.

II. Theory and Methods

The principal elements in sampling are the weight of the sample and the method of taking and handling it.

(1) Weight of Sample

To sample a given lot of material properly, it is necessary to know how small a portion may be taken and still keep within the allowable limits of error.

In an accurate sample a certain number of pieces must be present regardless of the size of those pieces, but depending upon the complexity of the material to be sampled. Obviously when all pieces are identical in composition, one is enough for a sample, but where the components differ greatly many pieces are necessary.

Obviously many 6-inch pieces weigh far more than the same number of one inch, and therefore different weights of samples are necessary for different sizes of material.

Tables have been established giving weights of samples necessary to attain accuracy with given sizes and complexities of material. To provide for uncertainties, the weights used should be those known to be accurate for even greater complexity than the particular lot in question. Since the pieces are always of unequal sizes the tables of weights of the sample are based on the size of the largest pieces in the lot.

Table I gives minimum sample weights for feldspar and quartz, respectively, the most and least complicated of ceramic materials.

An accurate sample of 6-inch and smaller feldspar pieces weighs at least 4632 pounds. To obtain a 129-pound sample the whole $2^1/_2$ tons must be crushed to 1 inch and finer.

* Presented at the Annual Meeting, American Ceramic Society, Washington D. C., February, 1932 (White Wares Division).

To get a 10-pound sample the 129 pounds must be crushed to $^1/_4$ inch, and to obtain a $^1/_2$-gram sample the 10 pounds must be reduced to 200-mesh.

(2) Segregation A sample of correct weight for its size of particles is not necessarily an accurate sample. It is inaccurate unless the method of taking it insures its being representative of the lot in question. Segregation must be carefully taken into account.

TABLE I

MINIMUM SAMPLE WEIGHTS AT DIFFERENT PARTICLE SIZES

Diameter of largest piece		Pounds	
Inches	Mesh	A Feldspar	B Quartz
12		18,528	4819
6		4,632	1177.2
4		2,064	523.2
2		516	130.8
1		129	32.7
0.75		72.4	18.4
0.5		32.2	8.1
0.25		8.05	2.04
0.131	6	2.21	0.561
0.065	12	0.55	0.138
0.0328	20	0.14	0.035
0.0164	40	0.034	0.0088
0.0082	70	0.0087	0.0022
0.0058	100	0.0043	0.0011
0.0041	150	0.0022	
0.0029	200	0.0011	

NOTE: Weights at different sizes are taken, proportional to the squares of the diameters, starting in each case with $^1/_2$-gram samples, at 200- and 100-mesh, respectively. The feldspar table has been found reliable in practical operation. The allowable error is within that of a high standard of accuracy for silicate analysis.

A solution is homogeneous and, for practical purposes, clay in a state of fine suspension may be considered free from segregation, so that a small portion taken at random would be an accurate sample. But when dry, all ceramic materials vary, due to segregation of particle sizes and usually of particle qualities. For this reason a random scoopful from a car of clay is not an accurate sample although it is of sufficient weight. Sampling methods must always be such as to take care of segregation accurately.

III. Preliminary Sampling

(1) Grab Sampling The most common of hand-sampling methods is taking grab samples. Small and supposedly equal portions are taken with scoop, shovel, or hand at regular or random intervals from the lot of material. It is cheap, quick, but not accurate.

In grab sampling of bulk carloads of ceramic materials, grabs should be taken from 3 parallel rows and at least 12 places in all, or from one row which zigzags 3 times across the car from corner to corner. Further-

more, such samples should alternately be from the top, middle, and bottom of the car, and the portions should be equal in amount.

Grab samples of coarse, unground materials are unreliable.

(2) Pipe Sampling Pipe sampling is satisfactory for sampling fine material in cars and bins. Sample points should be evenly distributed similar to the plans for grab sampling. A pipe sampler has the advantage of taking equal columns of the material.

NOTE: The simplest form of sampler consists of a piece of pipe with the lower end sharpened and the upper end fitted with handles. It should be long enough to reach the bottom of the car or bin. Several modifications are in use, one being slotted with one edge of the slot turned out to force the material inside when the pipe is inserted and turned. Another has two slotted pipes, one within the other, the slots coinciding when the pipe is inserted. The outer pipe is then turned to seal the inner slot, and withdrawn. Still another type is larger at one end than the other to allow the material to enter more readily. Small pipe samplers are used to sample material in sacks or barrels. In cases where the material is tightly packed, as with ball clay, an auger sampler similar to an ordinary earth auger is recommended.

(3) Fractional Shoveling Fractional shoveling may be used in sampling while loading or unloading material. One out of every so many shovelsful is thrown aside for the sample. It is not recommended where there are pieces over 2 inches in diameter. The number of shovelfuls to be taken depends upon conditions. Every 100th shovelful should be adequate for shipments of fine material. The resulting sample could then be reduced by coning and quartering to the proper size for the laboratory.

(4) Hand-Sample Cutters Hand-sample cutters can be used where material flows through spouts if they are operated to conform to the rules for accurate manipulation of machine-sample cutters and are of similar design. Hand cutters require frequent attention and introduce the difficultly controlled human element.

(5) Reduction of Initial Sample The coarse material must be crushed, thoroughly mixed, and coned and quartered, to yield a weight of material which is adequate for the resulting maximum particle size.

Fine material should be mixed, coned, and quartered, or put through a Jones splitter enough times to leave a small laboratory sample.

(6) Coning and Quartering Coning and quartering is seldom correctly done. It may be used, not without great labor, on lots up to 50 tons.

In coning, after crushing to finer than 2-inch pieces, the material is shoveled into a conical pile, each shovelful being carefully dropped directly on the cone apex to obtain symmetrical distribution about the axis. Equal shovelfuls should be taken from successively different portions of the initial pile and dumped on the apex from successively adjacent

positions around the cone. The fines are then swept up and placed on top of the cone.

Starting at points near the bottom of the finished cone the material is dragged radially downward to form a circular, flat cake, working around the cone. The cake is marked off into equal quarters and the two opposite quarters are rejected. The remaining quarters are then shoveled into a pile and the whole process is repeated.

At best, coning and quartering is subject to error, and for samples up to one or two hundred pounds, a Jones splitter is more accurate and more simple.

(7) Machine Sampling Machine sampling obviates the personal-element errors, shortens the time required, and reduces the labor. It is limited in application because the material must be in motion and must be presented to the samplers in a stream.

Machine samplers are of two types: those which take part of the stream all of the time and those which take all of the stream at regular intervals.

The first type is unsatisfactory, and not all of the second type conform to accuracy requirements. Some machine samplers under certain conditions are less accurate than good hand methods.

The approved machine has a scoop which moves at a uniform speed across and entirely out of the stream of material. The distance between cutting edges must permit ready access of the coarsest pieces and the scoop must be deep enough to prevent particles from bouncing out. The stream should be constant. The cutting intervals should be frequent enough to catch changes in the material of the stream.

(8) Sampling Crude Feldspar In sampling 80-ton lots of crude feldspar the mine product containing large pieces is crushed to $-3/4$ inch. A $2\frac{1}{2}\%$-machine sample cut is roll-crushed to $-1/4$ inch and then a $2\frac{1}{2}\%$-machine sample, or 100 pounds, is put through a Jones splitter to obtain a small laboratory sample.

IV. Final Sampling

The laboratory sample is again crushed if need be, and further divided by riffles or by coning and quartering.

The riffles consist of a series of parallel troughs with open spaces between them. The sample is spread over the troughs with a flat shovel or pan, care being taken not to heap it above the troughs. Either the portion falling between the troughs or that which falls in them may be rejected.

The Jones splitter has no open spaces between the troughs, but the bottoms are steeply inclined first in one direction, then the other, so that

the material is divided and goes to two underneath pans. The riffle causes less loss from dust than does the Jones splitter.

V. Sampling in the Production of Ceramic Materials

The rapid advancement in feldspar control is due to accurate sampling. The uniformity and quality of feldspar shipments are higher than ever before, especially the uniformity. The feldspar mines of today, however, are no larger and no more uniform than formerly. Eye analysis of a pile of crude feldspar is no more accurate today than it was ten years ago. The sole reason for increased uniformity and quality is accurate sampling of the crude feldspar followed by accurate tests and analyses. Four feldspar mills now have automatic sampling units. Some of the other mills have improved in uniformity by the guidance of analyses of their ground product but not to the extent possible with machine sampling before grinding.

VI. Sampling in the Use of Ceramic Materials

Shipments of raw materials are not homogeneous lots of a definite material. All portions of a car of kaolin are not the same. A shipment of crude feldspar will vary appreciably from one end to the other and segregations will occur in a shipment of ground feldspar depending upon its kind, the number of bins used in processing, and the method of grinding. Feldspars high in free quartz and with a potash-to-soda ratio of less than 3 to 1 are more apt to show such a variation. Hoppered bins are excellent mixers and materially assist in reducing segregation. Continuous grinding gives better mixing and less segregation of lots of over 2 tons than does batch grinding.

Although variations are likely to be small in the case of fine materials, it is best for the consumer to use good sampling methods.

(1) Segregation of Particle Sizes If to avoid segregation of quality is not sufficient reason for the consumer's use of accurate sampling methods, the inevitable segregation of particle sizes in all raw materials is alone reason enough to condemn the all too common practice of taking a grab sample from the surface of the carload or bin of material. Coarse particles always tend to settle to the bottom in any lot of material.

(2) Relation of Composition to Particle Size It should further be kept in mind that the coarse portion is quite liable to differ from the fine portion in kind, analysis, and behavior of particles. This is true in clays, ground feldspar, and other ceramic materials.

Table II shows the differences between coarse and fine portions of a lot of 200-mesh commercial feldspar. A is the analysis of the original

sample. B is the analysis of the particles over 20μ in diameter which were separated by elutriation. D is the analysis of the particles below 2μ which were siphoned, while in suspension, from a settling tube. Analysis C of the portion between 20 and 2μ in size was calculated from A, B, and D. The mineral compositions were calculated from the analyses.

TABLE II

ANALYSES

	A (%)	B (%)	C (%)	D (%)
SiO_2	69.30	69.80	68.78	66.65
Al_2O_3	17.30	17.12	17.45	18.92
Fe_2O_3	0.10	0.08	0.13	0.06
CaO	0.42	0.40	0.44	0.60
MgO	Tr.	Tr.	Tr.	Tr.
K_2O	9.68	9.72	9.60	10.20
Na_2O	3.18	2.98	3.42	3.47
Loss	0.21	0.18	0.25	0.25
	100.19	100.28	100.07	100.15
MINERAL COMPOSITIONS				
Microcline	57.4	57.6	56.9	60.6
Albite	27.0	25.5	29.0	29.5
Anorthite	2.1	2.1	2.2	3.0
Quartz	11.9	13.3	10.1	4.6
Kaolin, etc.	1.6	1.5	1.8	2.3

Analyses of coarse and fine portions of 200-mesh commercial feldspar.
A = original material
B = portion with particles coarser than 20μ diam. 55.00%
C = portion with particles between 20μ and 2μ diam. 43.03%
D = portion with particles finer than 2μ diam. 1.97%

The major difference between the coarse and fine portions of Table II is in their respective quartz content. Quartz, although friable, strongly resists further fine grinding after reduction to 0.04 mm. diameter. Feldspar particles are more easily ground to finer sizes. This difference in hardness accounts for the concentration of feldspar in the extreme fines, and the concentration of quartz in the coarser portion.

It is also interesting to note from Table II the tendency toward concentration of soda feldspar in the extreme fines.

NOTE: Since unaltered soda feldspar is generally tougher than potash feldspar, this concentration of soda feldspar in the extreme fines is harder to explain and is not to be generally applicable until confirmed by tests of other feldspars.

More highly altered feldspars than those in Table II would in all probability show a much greater concentration of kaolin in the extreme fines.

Another interesting point in the analyses is the concentration of iron in C. The reason is probably much the same as in the case of the quartz, garnet in particular having similar grinding properties. The original sample contained very little mica, but were more of it present it would be most largely in the coarse portion.

(3) Importance of Particle Size in Ceramics

Table II in connection with segregation of particle sizes adds emphasis to the need of accurate sampling. It also has a distinct application to research work. The importance of particle size in ceramic materials deserves greater attention. It is quite likely that lack of such attention accounts in some part for the conflict existing between the reported results of so many ceramic investigations. Research data will become vastly more valuable when they include accurate chemical, microscopic, and particle-size analyses of the materials involved. To make such analyses accurate, sampling is a prime requisite.

VII. Sampling Methods for the User

The user generally receives ceramic materials in a powdered state. Methods of sampling them as given by the Standards Committee of the AMERICAN CERAMIC SOCIETY[1] are inconsistent. For whiting, the Committee recommended that cores be taken from 25% of the containers with a sampling tube, and for lime that 3% of the containers be dumped and sampled by fractional shoveling, 1 shovel for 3 tons.

It is difficult enough to have men sample accurately without having several methods for them to follow. It is best that one process be followed with all shipments of fine materials, basing the process on that adapted for accurate sampling of the most variable material. Because of the difficulty of getting men to carry out fractional shoveling and coning and quartering properly, it is recommended that pipe samplers be used for shipments both in containers and in bulk.

At least 5% of the containers should be so sampled. Bulk carloads should be sampled at 12 places in a 30-ton car and 15 in a 50-ton car, arranged in 3 parallel rows and equidistant in each row. The pipe should be inserted to the bottom to secure a representative column.

For ball clay an auger is recommended.

All initial samples should be mixed and preferably reduced to the proper size with a Jones splitter.

Proper labelling is to be insisted upon. Sampling should be done or supervised by the laboratory.

VIII. Conclusion

Accurate sampling requires conscientious application of a rigid and correct routine because sampling errors are not easily detected. Segregation of particle sizes is sufficient reason alone for accurate sampling, especially since the coarse and fine portions of ceramic materials are found to differ in composition. This fact is added argument for the growing belief that particle size of ceramic materials deserves much more atten-

[1] *Jour. Amer. Ceram. Soc.*, **11** [6], 442 (1928).

tion. Accurate sampling is the first step in control of production. The expenditure of time and money in testing inaccurate samples is largely wasted, and plant control suffers in consequence.

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EDITOR'S NOTE: There are scores of references that could be cited but only the following are given for the benefit of our members not in touch with technical libraries.

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NOTES ON TUNNEL KILN CAR LUBRICATION*

BY J. T. ROBSON

ABSTRACT

A discussion of the properties required by oil for kiln-car lubrication is presented. The results reported on questionnaires answered by forty plants operating tunnel kilns are given, together with comments and conclusions therefrom. The residue, flash, and burning points of ten different oils approved for kiln-car lubrication are listed with directions for using oil as a lubricant on tunnel kiln cars.

I. Introduction

The consensus of opinion among oil producers and kiln-car users is that the flash and burning points of the lubricating oil are of the most vital importance. This may be true in a few rare cases where the temperature of the car bearings is sufficiently high to cause the oil to flash or burn, but even in such cases the heating-up is usually a gradual process so that actually the oil undergoes a distillation and by the time the maximum temperature is reached, there is not sufficient lubricant left to flash or burn; there is only the carbonaceous residue. It is this residue which has been found to be the cause of sticking or freezing of the roller bearings and consequent hard running of the wheels.

In general, the heavier the oil, the higher the flash and burning points, but also the greater the percentage residue, and, while the oil may be sufficiently heavy so that it does not all distill out while passing through the kiln the first time, when it has distilled out and left its residue, the amount of residue will be greater in proportion to the number of times the car has passed through the kiln than would be the residue from a lighter oil with lower flash and burning points and lower residue. This is only a general condition that applies to the ordinary rule: the heavier the oil

* Received February 23, 1932.

the greater the residue. Several oils (usually blended) have been found that are exceptions to the rule. They have high viscosity, flash, and burning points, and at the same time, low residue. Too light an oil can not be used, both because of its poorer lubrication property and also because of the fact that it will run out of the bearings too quickly. In one instance, a definite volume of oil suspended in a cup from the car frame showed a loss of 15% by volume when run through a 410-foot kiln where the undercar temperature was allowed to reach 400°F.

To make a study of results obtained in practice, a questionnaire was sent to tunnel-kiln operators. A total of forty plants having one or more kilns reported. The results can be summed up best by dividing the kilns into different groups according to the products fired and drawing general conclusions from the information contained on each sheet.

II. Comments

(1) Group I In Group I, one plant with 2 kilns uses graphite and kerosene. The undercar temperatures on these two kilns are 300°F and the kiln temperature, 1850°F. These kilns have been in operation 7½ years. The bearings are never cleaned except when worn parts are replaced. The cars do not run as easily as when installed.

Installation with 300°F undercar temperature tried graphite and kerosene but had better success with oil.

Although in all four cases where double-flanged wheels are used the cars run harder than when installed. The cause does not lie with the double-flanged wheels as shown by comparison with the other six installations. The cause is attributed as being due to wear of wheels, rails, and bearings, facilitated by the use of sand in setting which gets into the bearings and onto the rails, causing wear on both bearings and rails.

The two installations which have not removed bearings for cleaning in 2½ years' operation use oil for lubrication. One of these kilns has an undercar temperature of 450°F and the other is 270°F. The load in the former is light insulating brick and the latter is heavy quarry tile.

No definite conclusion could be drawn from the group as to the advisability of flushing with kerosene.

Four of the seven who oil cars just once each trip through the kiln have either a return track pusher or haulage system. Two of the other three have a light load and the third uses graphite-kerosene mixture.

(2) Group II In both cases where the cars run harder than when installed, the cause is attributed to worn bearings and axles. This is probably facilitated as in Group I by the presence of sand used in setting as well as the heavy load. The undercar temperature on one of these installations is 350°F and 260°F on the other.

No conclusion could be drawn as to the value of flushing with kerosene.

In both cases where the cars are lubricated but once each trip, a haulage system is used for conveying the cars outside the kiln.

(3) Group III Due to the lighter load and the absence of sand in setting, it can be seen that the cars run freely a longer time and with less difficulty than in the heavy-ware groups, I and II.

The installations which have not had bearings cleaned in six and eleven years' operation, use graphite in kerosene. The installation using Oildag, after six years with an undercar temperature of 360°F, has cars running

easier than when installed and the other installation using graphite has cars running as easily after eleven years' operation as when installed. The undercar temperature is only 180°F. The type of graphite used in this installation is United States Graphite Company No. 205 lubricating graphite. Another kiln that has been in operation four years employing an undercar temperature of 450°F had to clean out bearings annually when

	No. of plants reported	No. of kilns represented	Kiln temperature (°F)	Under-car temperature (°F)
Group I				
Face and common brick, Building tile, Roofing tile, Quarry tile	10	12	1830–2500	225–460
Group II				
Refractories	5	9	2300–2400	260–350
Group III				
Electric porcelain, Stoneware, Sanitary ware	7	9	2040–2300	180–450
Group IV				
Floor and wall tile	5	10	1700–2340	180–350
Group V				
Dinnerware, semiporcelain, and vitrified china	10	28	1800–2190	190–350
Group VI				
Artware	3	4	1900–2100	120–240

	Frequency of lubricating	Lubricant used	Flushed with kerosene when oil is used as lubricant
Group I	7 (once each trip through kiln)	1 (6 tsp. graphite + 1 gal. kerosene)	1 (once each trip through kiln)
	2 (twice each trip through kiln)	1 (1/2 kerosene + 1/2 oil)	4 (once every 30 days)
	1 (three times each trip through kiln)	8 (oil)	3 (do not flush with kerosene)
Group II	2 (once each trip through kiln	All use oil	2 (once each trip through kiln)
	3 (twice each trip through kiln)		1 (once every 6 weeks)
			2 (do not flush with kerosene)
Group III	5 (once each trip through kiln)	1 (1/2 cup Oildag + 1/2 gal. kerosene)	1 (once per month)
	2 (twice each trip through kiln)	2 (1 lb. graphite to 2 1/2 gal. kerosene)	6 (do not flush with kerosene)
		4 (oil)	1 (uses compressed air)
Group IV	All (twice each trip through kiln)	All use oil	1 (once per month)
			1 (once per month with 1/2 kerosene + 1/2 oil)
			3 (do not flush with kerosene)
			1 (uses compressed air)
Group V	1 (never lubricates)	1 (no lubricant)	1 (once every 30 days at entrance and exit ends of kiln)
	1 (once each trip through kiln)	9 (use oil)	1 (once every 6 weeks)
	8 (twice each trip through kiln)		1 (once every 2 or 3 months)
			1 (about once per year)
			6 (do not flush with kerosene)
Group VI	1 (once each trip through kiln)	All use oil	1 (once each time car is removed from kiln)
	2 (twice each trip through kiln)		1 (once every 30 days)
			1 (does not flush with kerosene)

	Removal and cleaning of bearings	Base of car movement	Type of wheel flanges
Group I	1 (av. every 6 months) 5 (av. every 12 months) 1 (av. every 18 months) 2 (never in 2½ years) 1 (never in 7½ years)	(a) 3 (move as easily as when installed 2½ to 5½ years) (b) 3 (some do and some do not move as easily as when installed; 2½ to 6 years) (c) 4 (run harder than when installed; 5 to 9 years)	a) 2 single, 1 double flange (b) 1 single, 2 double flange (c) 4 double flange
Group II	1 (once per year) 1 (once per 2 years) 1 (never in 8 months) 1 (never in 1½ years) 1 (very seldom in 5½ years)	(a) 3 (move as easily as when installed; 8 months to 5 years) (b) 2 (move harder than when installed; 5 to 5½ years)	(a) 1 single, 2 double flange (b) 2 double flange
Group III	1 (once every 4 months) 2 (seldom in 7 years) 1 (once per year with oil, not in 2 years with graphite) 1 (8 cars in 4 years) 1 (never in 11 years) 1 (never in 6 years)	(a) 1 (moves twice as easily as when installed; 6 years) (b) 5 (move as easily as when installed; 4 to 11 years) (c) 1 (moves harder than when installed; 7 years)	(a) 1 double flange (b) 1 single, 4 double flange (c) 1 double flange
Group IV	2 (never in 2½ and 3 years) 1 (never in 2 years on glost; only 3 or 4 cars on bisque) 1 (very seldom in 3 years) 1 (not in 18 months since using oil)	(a) 3 (move as easily or easier now than when installed; 2½ to 9 years) (b) 2 (move harder than when installed; 2 to 3 years)	(a) 2 single, 1 double flange (b) 1 single, 1 double flange
Group V	1 (once per year) 1 (80 cars in 4 years) 1 (75 cars on two kilns in 4 years) 1 (after 4 years cars start to require bearing cleaning) 1 (8 wheels on bisque kiln; none on glost kiln in one year operation) 1 (12 wheels in 4 years) 3 (never in 2 and 3 years) 1 (never in 6 years except for replacement; no lubricant used)	(a) 7 (run as easily as when installed; 1 to 4 years) (b) 1 (75% of cars run as easily as when installed; 3½ years) (c) 1 (not all cars run as easily as when installed; 5 years) (d) 1 (all cars run harder due to no lubrication)	(a) 4 single, 3 double flange (b) 1 double flange (c) 1 double flange (d) 1 double flange
Group VI	1 (seldom in 7 years) 2 (never in 2½ years)	All run harder than when installed; 2½ to 7 years)	2 single, 1 double flange

using oil. Since using graphite-kerosene for lubricant, no cars have been cleaned in the last two years. This company uses one pound No. 2 Dixon powdered flake graphite in ten quarts of kerosene.

Only one installation in this group seems to have any lubrication difficulty. Their undercar temperature is 350°F and no doubt it would be advisable for them to try graphite plus kerosene.

One of the installations using oil for lubrication and having cars run as easily as when installed four years ago, carries an undercar temperature of 400°F.

(4) Group IV One plant reported using kerosene and graphite but had to remove bearings frequently because of graphite clogging the rollers. Since using oil for the past eighteen months, it has been unnecessary to remove any bearings. For oil, a mixture of one part 600-W and one part kerosene is used. The undercar temperature is 240°F. This plant also blows out its bearings with compressed air at the exit end of the kiln before oiling.

In one case where the cars run harder than when installed, the undercar temperature has been raised from 260 to 350°F and the operator rightfully claims that this increase in temperature is the cause for running harder.

In the other installation where the cars are reported as running harder, the increase is not excessive.

In all three cases where the cars run as easy or easier than when installed the undercar temperature is kept below 300°F; one of these installations flushes once per month with kerosene, one flushes once per month with $^1/_2$ kerosene plus $^1/_2$ light oil, and another blows out the bearings each time at the exit end of the kiln with compressed air.

In this group there appears to be no difference between single-flanged and double-flanged wheels.

(5) Group V One plant used graphite plus kerosene for a time but discontinued it because of caking in the bearings.

No conclusion could be drawn in this group as to the value of flushing with kerosene.

In the installation where no lubricant is used, a haulage system is used to propel cars. The wheels need never be cleaned, but replacement of bearings is necessary.

A haulage system is also used in the installation where the cars are lubricated only when entering the kiln.

One plant reports that cars run hard if the undercar temperature goes above 250°F. Several other plants give 270°F as the maximum temperature for easy running cars. Another operator states that he can go up to 320°F undercar temperature before finding difficult car movement.

In this group, single- and double-flange wheels compare about the same.

(6) Group VI In this group relatively low undercar temperatures are used, yet strangely enough, on all three installations the cars run somewhat harder than when installed, even though they are using a good grade of approved oil.

One operator reports that increasing the undercar temperature from 120 to 220°F caused harder running cars.

III. Conclusions

From these observations and experiences of tunnel kiln operators over a number of years, it can be seen that in the majority of cases, the car lubrication problem is not a serious one.

There is no difference in ease of car movement between single- and double-flanged wheels.

No positive conclusion can be drawn as to the merits of graphite *versus* oil for kiln-car lubrication. It does appear that when the undercar temperature runs 350°F or above, graphite mixed in the proportion of about one pound of very fine or colloidal graphite to one bucket or ten quarts of kerosene may be more satisfactory than oil. Anyone who is employing a high undercar temperature and having trouble with oil as a lubricant, should try the graphite-kerosene mix. The operators using graphite and kerosene mix state that this mixture must be thoroughly stirred each time before using. The use of colloidal or very fine graphite will help to prevent the settling out of the graphite in the kerosene.

The use of compressed air to blow out the bearings at the discharge end of the kiln appears to be desirable where compressed air is available.

Past experience and the reports show that when oil of higher residue than 0.6% is used, trouble with clogging of the bearings has resulted.

Practically all the leading oil companies can supply an oil for this purpose with a residue below 0.6%.

Before recommending oil for kiln-car lubrication, residue, viscosity, flash, and burning-point tests are run, and sometimes a distillation test. Thus far sufficient data on distillation tests have not been secured to draw any worthwhile comparisons. The residue is determined by the Conradson method. Some of the oils tested in the laboratory and recommended for use run as follows:

Oil	Residue (%)	Flash point (°F)	Burning point (°F)
1	0.03	486	570
2	0.08	395	455
3	0.12	520	528
4	0.14	492	562
5	0.14	422	486
6	0.22	383	464
7	0.28	492	562
8	0.39	423	498
9	0.46	423	518
10	0.59	400	520

In using oil as a lubricant therefore, the following points should be conformed with:

(1) Use an oil with a carbon residue below 0.6%.

(2) Use an oil of sufficient viscosity to remain in the bearings so as not to run out before coating all bearings as the wheel rotates.

(3) The cars should be pushed a short distance immediately after oiling in order to work the oil around the complete circumference of the axles and rollers.

(4) When oiling at the exit end of the kiln, do not oil the warm car as soon as it comes from the kiln, but allow it to cool and then oil just before it is time to pull out another car.

(5) While no definite conclusion can be drawn as to the merits of using kerosene for flushing bearings, it is evident that no harm can be done by doing so and it would therefore appear advisable to flush with kerosene about once every thirty days. By using kerosene on the car when cold, it will be found that the car does not push excessively hard. Kerosene should be used at the exit end in most cases so that the long, more rapid push down the return track will tend to break up and discharge the carbon residue.

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CERAMIC ABSTRACTS[1]

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Vol. 11 **August, 1932** **No. 8**

Abrasives

Fixed method in grinding cemented tungsten carbide tools. H. W. Wagner. *Automotive Ind.*, **62**, 370–73 (1930).—The final shaping of cemented tungsten carbide tools must be effected by means of a grinding wheel, an abrasive hone, or by loose abrasive. Grinding wheels must be soft enough to retain their sharpness by wear, but hard enough to retain their shapes for a reasonable time. The tool may be held in the hand or held in the machine, the pressure being regulated by a spring. W. mentions causes for poor results in grinding and suggests remedies. For straight-in feed, 0.0005 in. per cycle of two passes is good practice. With a cross feed of 0.030 in. per pass, a direct feed of 0.003 in. per pass is recommended. Wet grinding produces quicker results but requires a harder wheel than does dry grinding. Lapping and honing is done on revolving disks of metal with silicon carbide, boron carbide, or diamond powder. For good finish, accuracy of clearance angles, and keenness of edge the fixed method of grinding is preferable to the free-hand method. H.F.V.

Variety in buffing compounds. Henry R. Power. *Metal Cleaning & Finishing*, **4** [5], 301–302 (1932).—Some of the physical forces at play in buffing are enumerated and discussed. E.J.V.

PATENTS

Chuckless and centerless machining device. O. R. Briney. U. S. 1,858,235, May 17, 1932.

Abrading machine. Willy Fromm (United Shoe Machinery Corp.). U. S. 1,858,297, May 17, 1932.

Electric grinder. C. H. Beach (Dumore Co.). U. S. 1,859,068, May 17, 1932.

Centerless grinder. H. J. Hoeg. U. S. 1,859,443, May 24, 1932.

Column turning, honing, and polishing machine. D. M. Mills (Musto-Keenan Co.). U. S. 1,859,595, May 24, 1932.

Grinding machine. W. J. Guild (Heald Machine Co.). U. S. 1,859,737, May 24, 1932. H. H. Yerk and W. J. Baumberger (Micro Machine Co.). U. S. 1,860,795, May 31, 1932. H. H. Yerk and A. A. Kottman (Micro Machine Co.). U. S. 1,860,796, May 31, 1932. M. I. Mathewson (Brown & Sharpe Mfg. Co.). U. S. 1,861,279, May 31, 1932. K. F. Gallimore (Heald Machine Co.). U. S. 1,862,215, June 7, 1932. H. F. Koestlin. U. S. 1,862,379, June 7, 1932.

Tool grinder. W. F. Stimpson. U. S. 1,860,211, May 24, 1932.

Mechanism for truing and dressing grinding wheels of centerless grinders. F. J. Hohnhorst and F. J. Kroeger. U. S. 1,860,614, May 31, 1932.

Process for making polishing and grinding material. F. A. Schumacher (Security Grinding Wheel Co.). U. S. 1,860,724, May 31, 1932.

Dressing tool. Rupert Andersson. U. S. 1,860,764, May 31, 1932.

Axle grinder. H. H. Yerk and W. J. Baumberger (Micro Machine Co.). U. S. 1,860,794, May 31, 1932.

Abrasive device. F. O. Albertson and G. A. Olsen (Albertson & Co., Inc.).

[1] The abbreviation (*C.A.*) at the end of an abstract indicates that it was obtained from *Chemical Abstracts* by coöperative agreement.
The bold-face number following the journal name is the volume, the issue number is in brackets followed by the page numbers, then the year in parentheses.

U. S. 1,861,773, June 7, 1932. A flexible pad carried by a hub and adapted to flex relative to the hub, and a plurality of thin and flexible disks located on the face of the pad for providing it with a predetermined degree of flexibility and local resiliency.

Chuck. G. E. GARNO (Heald Machine Co.). U. S. 1,862,216, June 7, 1932.

Buffing machine. CHARLES R. MOON (Ontario Mfg. Co.). U. S. 1,862,277, June 7, 1932.

Grinding or abrading machines. W. W. TRIGGS (Norton Co.). Brit. 371,425, May 4, 1932. S. OSBORN & CO., LTD., AND W. WORSLEY. Brit. 372,419, May 19, 1932.

Device for dressing circular abrasive disks. A. LEBERT. Brit. 371,754, May 4, 1932.

Apparatus for cleaning and similarly treating articles by projected abrasive materials. C. J. FEENY (H. A. Mulvany). Brit. 371,756, May 4, 1932.

Gear grinder. W. W. TRIGGS (Pratt & Whitney Co.). Brit. 371,987, May 11, 1932.

Grinding or flutter disk. A. LEBERT. Brit. 372,220, May 11, 1932.

Cylindrical grinding or abrading machines. CHURCHILL MACHINE TOOL CO., LTD., AND H. H. ASBRIDGE. Brit. 373,056, May 25, 1932.

Art and Archaeology

Notes on the metal plating of glass and porcelain. F. FRANCESCHINI. *Ind. Silicati*, **10** [4], 7–9 (1932).—Methods for covering objects of glass, porcelain, terra cotta, plaster, or wax with a layer of metal are given. Directions for copper plating are as follows: By means of a brush the object is covered with a layer of conductive material composed of a solution of gold chloride or platinum chloride reduced with a balsam of sulphur or oil of turpentine in which sulphur is dissolved. The object is heated slightly and again coated to make the layer thicker; it is then heated in a muffle kiln until a bright metal layer is formed which makes it suitable for copper plating. The object is placed in a copper bath where it serves as an electrode and is subjected to the action of a current of 3 volts for a short time. It is well washed, placed in boiling water for a moment, dried with sawdust, and given a coat of transparent lacquer to prevent the copper from oxidizing. The copper bath must be alkaline and contain potassium cyanide which makes precipitation gradual and homogeneous. The following recipe is given for a copper bath: Eight kg. of copper cyanide of potassium is dissolved in 30 liters of hot water; 200 g. of cyanide of potassium 99% is added, then 100 g. of powdered soda. The mixture is filtered the solution diluted with 100 liters of water, and 200 g. of crystallized ammoniacal chloride are added. This bath works well at a temperature of 20 to 25° and with a current of 2.5 to 3 volts. For light copper plating the following bath is advised: Three kg. of neutral acetate of crystallized copper are dissolved in 25 liters of hot water; 1.85 kg. of pulverized soda is gradually added, stirring continuously, and then 3.75 kg. of sodium bisulphate. In the greenish solution thus obtained, 3.75 kg. of 99% cyanide of potassium is sifted until the bath becomes clear, when 1.5 kg. of crystallized ammoniacal chloride is added. This solution is then diluted with up to 100 liters of water and the bath is used at 20 to 25° with a current of 2.7 to 3.5 volts. For a small quantity, earthenware basins are used; for a large bath, wood vats. The following processes are also described: (1) silver plating according to the method of Böttger, Wood, Brozette, Bory, Kayser, and Lumiere, (2) gold plating by the method of Böttger, (3) the methods of Vasserot, Dode, and Kundt for platinum plating, and (4) Kattaways method of copper plating. M.V.K.

Engraving and frosting of glass. JEAN DARIC. *Céram. verrerie*, **831**, 501–502 (1931).—The engraving and frosting of glass may be accomplished by either sandblasting or etching. With few exceptions the most satisfactory effects are accomplished by chemical means. For pieces that are small or moderate in size the etching method is most satisfactory. With heavy glass the sandblast is employed and etching is used to give a softening effect. For fragile pieces such as lamp bulbs, frosting methods are employed. The fundamental equation is $SiO_2 + 6HF = H_2SiF_6 + 2H_2O$. The reaction is more complex on account of the other oxides present. The engraving consists essentially in an attack by HF in water solution. The attack is most often localized in order to bring out lines or decorative motifs. It is necessary to prepare a coating on the surface which is to be engraved and which is resistant to HF. This varnish consists of Jew's pitch dissolved in a volatile solvent such as turpentine, benzine, or mineral oil with the addition of beeswax, pitch, stearin, or tallow. These coverings

are of two sorts, liquid varnish applied with a brush and a thick paste which is used for transfers. In the latter case printing methods are employed by using a lithographer's stone or a metal plate and covering with the paste. A thin sheet of paper is then placed over the plate and the varnish adheres to it. The paper is then transferred to the piece which is to be engraved. In either case after the design is placed on the piece it is dipped into the etching bath, allowed to stay the necessary time, and washed with water; the varnish is removed by volatile solvents or by ammonia solutions. The speed of attack depends upon the concentration of the acid, the constituents of the glass, the temperature of the bath, and the length of time the piece stays in the solution. The bath is kept at a temperature of from 15 to 20°C. The addition of HCl, H_2SO_4, and HNO_3 hastens the reaction. In case it is desired to have glossy and transparent etching 60% commercial HF is diluted with 4 to 10 parts of water. In practice it is best to diminish the concentration of the bath and to increase the time of immersion. In the case of crystal glass it is well to add HCl in the proportion of 10% of the HF used.

T.N.McV.

Studies of some chemical and physical properties of majolica enamels as functions of their composition. H. J. KARMAUS. *Sprechsaal*, **65** [19], 352–54; [20], 370–73 (1932).—(1) The technique of majolica enameling is described. (2) Two kinds of external forms of corrosion of the surfaces of majolica must be distinguished, (*a*) iridescent spots which are difficult to wash off and are caused by a too high lead oxide content, or (*b*) removable efflorescences appearing on the enamel when the content of alkalis is increased at the expense of lead oxide. (3) Methods for the numerical determination of the acid solubility and water solubility are given. (4) Different batches for durable majolica enamels are given with the results of tests and compared to alkali borosilicates. (5) No definite limits for the composition of stable majolica enamels can be given because neither does the acid solubility depend on the absolute value of the PbO content, nor the water solubility on the absolute value of the alkali content, but both properties depend greatly on the ratio between other components of the enamel. (6) The grit testing methods given for determining solubility can be used only for majolica enamel and not for other enamels free from lead. (7) Majolica enamels free from lead have not yet fulfilled expectations. M.V.K.

Art of shaping vases. I to VI. COSIMO ETTORRE. *Ind. Silicati*, **9** [5], 13–14; [7], 13–14; [9], 12–13; [11], 14–16 (1931); **10** [1], 11–12; [3], 15–16 (1932).—A complete treatise is presented on the rational method of procedure in shaping vases on the potter's wheel. The subjects discussed are (1) the early Egyptian wheel, (2) the foot wheel of the Athenian, Dedalo, (3) the nomenclature of the parts of the potter's wheel, (4) preparation of the mass, (5) how the clay mass is shaped into a vase, (6) shaping large vases of several parts, (7) handles and ornaments, and (8) defects and their correction, including uneven bases, bases which are too thin at the center, bases too thick or thick only at the side, irregular thickness of the walls, and rims that are too thick or too thin. M.V.K.

Enameled wall tile. FRANC ELIAS. *Corriere Ceram.*, **13** [3], 97–101 (1932).—A greater use in architecture of the wide variety of coloring and design offered by ceramic ware, especially enameled wall plates of terra cotta, majolica, or stoneware, in Spain and other countries with mild climate is urged. M.V.K.

Italian pottery. ANON. *Sprechsaal*, **65** [18], 327 (1932).—The materials used, methods of preparing, firing, and glazing of pottery in small Italian plants are described. M.V.K.

Crystal ware with colonial trimmings. CORNING GLASS WORKS. *Ceram. Ind.*, **18** [5], 299 (1932).—The Steuben Division of the Corning (N. Y.) Glass Works is producing a new line of table glassware including stemware in several sizes, plates in several sizes, and odd-shaped centerpiece candlesticks. These are all reeded with two lines only, one in a rich ruby and the other in a rich blue. W.W.M.

Ensemble table service. ANON. *Christian Sci. Mon.*, **24** [119], 5 (1932).—Matching designs in silver and tableware are discussed. Illustrated. E.J.V.

Adaptability of pottery. ANON. *Christian Sci. Mon.*, **24** [144], 9 (1932). E.J.V.

Repairing china. ANON. *Christian Sci. Mon.*, **24** [119], 5 (1932).—The methods of mending broken china by use of cement to be fired, and of using cold china mending cement which dries extremely hard without firing, are described in detail. E.J.V.

Modern German church art. WALTER RENDELL STOREY. *Creative Art*, **10** [1], 45–52 (1932).—The modern mode has completely supplanted traditional styles in recent ecclesiastical architecture and decorative crafts. Economy in construction and use of contemporary building materials and methods are important factors. Glass plays a leading rôle in many of the churches. The ultimate in churches of glass is the evangelical

church of steel and glass by Bartning of Berlin. The walls are all of leaded glass. Illustrated. M.J.G.W.

Artist in stained glass. ANON. *Christian Sci. Mon.*, **24** [128], 6 (1932).—Barbara Batt, a young English artist who makes stained-glass windows, is providing unusual designs for domestic purposes by using figures adapted from old brass rubbings. Some of her work is described. Illustrated. E.J.V.

Henri Navarre, a glass artist. JEAN GALLOTTI. *Art et Déc.*, pp. 41–50 (Feb., 1932).—The following work of Henri Navarre is described and illustrated: (1) heavy glass for portraiture masks, (2) raised architectural effects and slightly blown pieces of unusual massiveness, all relief being applied with liquid glass, (3) an interesting figure of Christ in the chapel of the S. S. Ile de France, and (4) architectural examples in the college of the Japanese students of Cité Universitaire. M.J.G.W.

Gian Carlo Polidori. ANON. *Corriere Ceram.*, **13** [3], 111 (1932).—The "Gaetano Ballardini" prize of 1931 of the Comune of Faenza went to Gian Carlo Polidori for the novelty and beauty of his work in ceramics. M.V.K.

Jean Besnard, potter and ceramist. RENÉ-JEAN. *Art et Déc.*, pp. 19–28 (January, 1932).—Interesting potteries, stoneware executed on the wheel, turned sculpture, barbaric and modern effects, and designs applied mechanically and blown on with powdered glaze are described and illustrated. See also *Ceram. Abs.*, **11** [6], 340 (1932). M.J.G.W.

Meissen ware. FRANK DAVIS. *Illus. London News*, **180**, 488 (1932).—Illustrated specimens from the collection of the late Ernest Cassel are presented. H.H.S.

Danish applied art. S. SCHULZ AND M. BODELSEN. *Danish Foreign Office Jour.*, **12**, 1–12 (1932).—A permanent exhibition of Danish art handicrafts and applied art has been installed at Copenhagen. Illustrated. H.H.S.

New relics of a great period in Persian art. A. U. POPE. *Illus. London News*, **180**, 482–84 (1932).—A Sassanian palace has been found by the Pennsylvania expedition at Damghan in northern Persia. H.H.S.

Exposition of old stoneware in Paris. ANON. *Sprechsaal*, **65** [20], 380 (1932).—An exposition of the Louvre of old stoneware is described. About 3000 objects representing different French schools and beginning with the 16th Century are shown. The oldest objects (1525) were manufactured at St. Porchair and belonged to the court of King Henry II. The famous school of Nevers with its remarkable relief work is represented by numerous vases, dishes, etc. Objects of Paris, St. Cloud, Chantilly, and Mennecy can also be seen. This exposition is a history of the art of French stoneware. M.V.K.

Gilt glass of the Roman Imperial period. CHRISTINE ALEXANDER. *Bull. Met. Mus. Art*, **26** [12], 288–89 (1931).—A gilt-glass medallion with a pagan subject and inscription has been added to the classical collection of glass. There are very few complete cups of this kind but bottoms of cups are numerous. The scene is a charioteer driving a four-horse chariot, holding in his left hand the palm received for victory in the race. These gilt glasses were made by attaching a sheet of gold leaf to the outside of the cup and cutting out the design and inscription in it. Some colors were added, another layer of glass was applied, and the whole fused together. This process is a difficult one and modern experimenters have not been entirely successful in imitating it. This cup was found in a Roman catacomb and has been dated from the middle of the 3rd Century. A.A.A.

A stand by Kleitias and an Athenian jug. G. M. A. RICHTER. *Bull. Met. Mus. Art*, **26** [12], 289–94 (1931).—Two pieces of early Greek pottery of unusual importance are shown this month in the Room of Recent Accessions. A.A.A.

Buffalo motif in middle Celebes decorative design. WALTER HOUGH. *Proc. U. S. Nat. Mus.*, **79** [2895], 1–8 (1932).—The study of a general collection of bark cloth, carved hooks and spoons, gourd, coconut, and bamboo containers etched with designs, and a horn-weaving frame discloses the use of the water buffalo as the principal motif of Malay decoration on the middle Celebes. The complete buffalo designs were segmented by the artists and used in various sequences. The segments used were the horns in pairs and singly, the eyes, the ears, and a diamond figure placed in the area between the eyes and the base of the bull's horns. 9 plates. J.L.G.

Ancient caves of Szechwan Province, China. DAVID CROCKETT GRAHAM. *Proc. U. S. Nat. Mus.*, **80** [2916], 1–13 (1932).—Thousands of artificial caves chiseled out of solid sandstone on the sides of hills and cliffs are to be found in the western part of China in the Province of Szechwan. The popular belief is that these were made and used as dwellings by the aborigines who inhabited Szechwan Province before the arrival of the Chinese. From the evidence of the coffins, clay figures, pottery, and wall carvings

found there, G. concludes, however, that the caves are Chinese tombs constructed for burial purposes in the Han dynasty (206 B.C. to 220 A.D.) or possibly during the early years of the three kingdoms. 14 small text figures and 16 plates. J.L.G.

Excavations at a prehistoric Indian village site in Mississippi. HENRY B. COLLINS, JR. *Proc. U. S. Nat. Mus.*, **79** [2898], 1–22 (1932).—Three house rings or circular ditches were uncovered at Deasonville, Miss. These contained post holes arranged at regular intervals along the bottom of the rings. The rings varied from a depth of 2 in., a width of 10 in., and a diameter of 38 ft. in the smallest to a depth of $2^1/_2$ ft., a width of 19 in., and a diameter of over 60 ft. in the largest. The rings were filled with refuse. Fire pits and post holes were found in each of the house rings. A study of the potsherds found failed to reveal any clues which might be of value in placing the site chronologically beyond the fact that it is prehistoric. 13 plates. J.L.G.

English delft. FRANK DAVIS. *Illus. London News*, **180**, 400 (1932).—Five illustrations are given from the group of small potteries which became known as Lambeth Delft. H.H.S.

German porcelain. STEFAN PRIACEL. *Art et Déc.*, pp. 81–88 (March, 1932).—A short history of German potteries since the time of Boettger is given. The quantity production ware is produced mainly in gray and pink and the shapes are not highly original. Illustrated. M.J.G.W.

Discoveries at Athens. T. L. SHEAR. *Discovery*, **13**, 75–78 (1932).—An illustrated account is given of the first season's work at the Agora of Athens where the shops of the potters were located, yielding abundant pottery. See also *Ceram. Abs.*, **11** [1], 7 (1932). H.H.S.

Culture of the Campas Indians. B. G. CALDWELL AND J. CALHOUN. *Sci. Monthly*, **34**, 238–42 (1932).—The Campas Indians are located in Peru. Their pottery is a yellowish riverbank clay decorated with dyes made from the bark and roots of a tree. H.H.S.

Ras Shamra links with Egypt. F. A. C. SCHAEFFER. *Illus. London News*, **180**, 382–84 (1932).—Pottery and other finds in northern Syria show that Ras Shamra in the 20th Century B.C. had close relations with Egypt of the Twelfth Dynasty. H.H.S.

Further discoveries at Ur. C. L. WOOLLEY. *Illus. London News*, **180**, 421 (1932).—The season's discoveries to date of the British Museum-University of Pennsylvania expedition are described and illustrated. See also *Ceram. Abs.*, **10** [7], 479 (1931). H.H.S.

The "Castle of the Disc" at Tell-el-Amarna. J. D. S. PENDLEBURY. *Illus. London News*, **180**, 427–29 (1932).—The story of excavations at the ephemeral city built by the heretic Pharaoh Akhenaten is continued. See also *Ceram. Abs.*, **11** [1], 7 (1932). H.H.S.

Dutch tile stoves as a record of culture. MICHAEL BIRKENBIHL. *Sprechsaal*, **65** [19], 347–50 (1932).—The development of the Renaissance, Baroque, and Rococo styles in Dutch tile stoves of the 16th, 17th, and 18th Centuries is discussed. Illustrated. M.V.K.

Ceramics of Tell Halaf. ANON. *Sprechsaal*, **65** [19], 363 (1932).—Ceramic objects excavated from the ruins of Tell Halaf near Aleppo, Mesopotamia, and shown in Berlin are described. The objects show an extraordinary diversification in regard to the motifs of coloring and shaping of the ware. They resemble closely the ceramics of Susa, Samarra, Kerkuk, and other subaraishhettitic towns, while the terra cotta statuettes are similar to those found in Ur. Tell Halaf must have been destroyed about 2000 years B.C. See also *Ceram. Abs.*, **10** [3], 169 (1931). M.V.K.

Museum of glassware at Murano. F. URBANI DE GHELTOF. *Ind. Silicati*, **10** [4], 14–15 (1932).—The collection of glassware shown at the Murano museum is discussed. M.V.K.

BOOKS

Aert Schouman and the Glasses That He Engraved. WILFRED BUCKLEY. 50 pp. 30 plates. Ernest Benn, Ltd., London, 1932. Price 25s. Reviewed in *Times Lit. Supp.*, **31**, 203 (1932).—A supplementary note is given on glasses engraved by Frans Greenwood. See also *Ceram. Abs.*, **11** [7], 399 (1932). H.H.S.

Art of the Potter. HARRY BARNARD. A. & C. Black, Ltd., London. Price 2s 6d net. 89 pp. *Pottery Gaz.*, **57** [659], 603 (1932).—This is a practical exposition, informative without being unduly technical, in which B. sketches the potter's art, its birth, and development. E.J.V.

Minoan Art. E. J. FORSDYKE. 30 pp. 12 plates. Univ. Press, Oxford. Price

6s 6d. Reviewed in *Times Lit. Supp.*, **31**, 203 (1932).—A lecture to the British Academy is given. H.H.S.

Archaeology of Santa Marta, Colombia: The Tairona Culture: Part I. Report on Field Work. J. ALDEN MASON. 130 pp. 64 plates. Field Museum, Chicago, 1932. Price $1.75. Reviewed in *Times Lit. Supp.*, **31**, 156 (1932). H.H.S.

PATENTS

Unitary water-closet bowl and tank. GEORGE BRAIN (Standard Sanitary Mfg. Co.). U. S. 86,995, May 24, 1932.

Design for cruet, etc. H. R. MCDONALD (Hart Glass Mfg. Co.). U. S. 87,014, May 24, 1932.

Design for plate. KARL PSCHORR (Schumann China Corp.). U. S. 87,022 and 87,023, May 24, 1932. R. E. LUKENS (Mayer China Co.). U. S. 87,037, May 24, 1932. W. S. MAYER (Mayer China Co.). U. S. 87,038, May 24, 1932. A. R. APPLE (Wallace China Co., Ltd.). U. S. 87,042, May 31, 1932. J. B. MCDONALD (Edwin M. Knowles China Co.). U. S. 87,122, June 7, 1932.

Design for range. JACOB TELLER AND A. P. SCHULZ (Teller Stove Designing Corp.). U. S. 87,032, May 24, 1932.

Design for jar. H. S. WADE (Owens-Illinois Glass Co.). U. S. 87,047, May 31, 1932. W. E. GARVEY (Salem Glass Works). U. S. 87,051, May 31, 1932.

Design for bottle. H. T. CUMMING (Curtice Brothers Co.). U. S. 87,048, May 31, 1932.

Design for vase. J. S. HALL (L. E. Smith Glass Co.). U. S. 87,058, May 31, 1932.

Design for cooking stove. B. B. KAHN (Estate Stove Co.). U. S. 87,065, May 31, 1932. M. G. KLEMME. U. S. 87,066, May 31, 1932.

Design for shade. H. A. BUCCINI AND S. H. BARNES (Gleason-Tiebout Glass Co.). U. S. 87,102, June 7, 1932.

Design for street-light globe. H. W. DAVIDSON. U. S. 87,103, June 7, 1932.

Design for pitcher. J. B. MCDONALD (Edwin M. Knowles China Co.). U. S. 87,120, June 7, 1932.

Design for covered dish. J. B. MCDONALD (Edwin M. Knowles China Co.). U. S. 87,121, June 7, 1932.

Design for cup. J. B. MCDONALD (Edwin M. Knowles China Co.). U. S. 87,123, June 7, 1932.

Cements

Studies on synthesis of calcium silicate. IV. SHOICHIRO NAGAI AND KEIICHI AKIYAMA. *Jour. Soc. Chem. Ind.* [Japan], **35** [3], 118–23*B* (1932).—The thermal syntheses of calcium silicates in the presence of Al_2O_3 and Fe_2O_3 were studied. It was found that (1) the presence of Al_2O_3 is necessary for the formation of $3CaO \cdot SiO_2$ when Portland cement clinker is heated but its effect is less than that of Fe_2O_3, and (2) the molecular ratio of combined CaO to combined SiO_2 in calcium silicates becomes gradually greater in proportion to the amounts of Al_2O_3 and Fe_2O_3. Diagrams show the relative effect of these sesquioxides. For Part III see *Ceram. Abs.*, **11** [6], 343 (1932). M.V.K.

Studies on the hydrothermal synthesis of calcium silicates at ordinary temperatures. II and III. SHOICHIRO NAGAI. *Jour. Soc. Chem. Ind.* [Japan], **34** [11], 418*B* (1931); **35** [4], 153–56*B* (1932).—Mixtures of CaO and SiO_2 (1:1) were heated for 10 to 20 hr. at 800 to 900° at atmospheric pressure. The results show that $3CaO \cdot 2SiO_2$ is first produced at 800°C but changes gradually to $CaO \cdot SiO_2$ with longer heating. On heating to 900°C or above $2CaO \cdot SiO_2$ is produced at first but it changes to $3CaO \cdot 2SiO_2$ and then to $CaO \cdot SiO_2$. In mixtures of 3CaO and $2SiO_2$ (3:2), $3CaO \cdot 2SiO_2$ was produced first but changed easily to $2CaO \cdot SiO_2$. Results on the thermal synthesis of calcium silicates in mixtures of calcium carbonate and silica in different proportions are also given. For Part I see *Ceram. Abs.*, **11** [6], 343 (1932). M.V.K.

Concluding remarks on alite. A. GUTTMANN AND F. GILLE. *Rock Prod.*, **35** [9], 59–60 (1932); for abstract see *Ceram. Abs.*, **11** [2], 78 (1932). W.W.M.

Manufacture of Portland cement. I and II. Definition of Portland cement, composition, manufacturing process, and costs. S. E. HUTTON. *Rock Prod.*, **35** [6], 18–19; [8], 32–33 (1932).—H. defines and gives the composition of Portland cement and the kinds and sources of raw materials. He describes the manufacture of cement and

classifies the costs of putting cement on the market. The problem of plant location is discussed. W.W.M.

Raw materials used in the manufacture of Portland cement. C. R. PLATZMANN. *Zement*, **21**, No. 4 (1932); *Rev. mat. constr. trav. pub.*, No. 271, pp. 151–53 (1932).—P. discusses and analyzes different calcareous and argillaceous raw materials used in the manufacture of Portland cement in Germany, Great Britain, France, Belgium, Spain, Denmark, Dalmatia, U. S., Mexico, Australia, South Africa, India, and Japan. M.V.K.

Change in period of set of Portland cement due to storage. HELLMUT WEITHASE. *Zement*, **20** [9], 187-92 (1931); *Rock Prod.*, **35** [8], 58–59 (1932).—W. reviews the literature available on the subject of effect of storage of Portland cement on its period of set, and reports on his investigations. W.W.M.

Compounds of the CaO–Fe_2O_3 system and their rôle in Portland cement. J. KONARZEWSKI. *Roczniki Chem.*, **11** [6], 516–28 (1931); *Chim. & ind.*, **27** [1], 104 (1932). M.V.K.

Dusting of Portland cement clinker. ALTON J. BLANK. *Rock Prod.*, **35** [8], 44–45 (1932).—B. cites literature on the dusting of Portland cement and describes and tabulates some of his work on the problem. He concludes that there are a number of factors which cause the dusting of cement and that they vary with the plant and the raw materials. W.W.M.

Studies on aluminous cements. I. RENATO SALMONI. *Giorn. chim. ind. applicata*, **14** [3], 133–36 (1932).—The first results of a study of the thermal phenomena which accompany the setting of aluminous cement mixed either with water or solutions of bases, acids, and salts are given. See also *Ceram. Abs.*, **11** [6], 344 (1932). M.V.K.

Aluminous cements. H. VIERHELLER. *Tonind.-Ztg.*, **56** [36], 470–71 (1932).—The strength of aluminous cements was investigated at room and elevated temperatures. Contrary to Haegermann (see following abstract) no appreciable decrease in strength was observed. W.M.C.

Alumina cement. HAEGERMANN. *Tonind.-Ztg.*, **55** [103], 1430–31 (1931).—The highest strength of alumina cement is secured by a temperature of 15 to 20°C. Lower and higher temperatures delay the hardening process. The treatment of the set mortar by vapor is harmful. With the usual cement, the hardening process is accelerated with rising temperature (up to 50°C), and the vapor treatment of the set mortar increases the strength considerably. W.M.C.

Iron in the constitution of cement and ferrous cement. G. SESTINI AND L. SANTARELLI. *Rev. mat. constr. trav. pub.*, No. 271, p. 143 (1932).—By means of microscopical examinations the authors found that ferrous cements are rich in alite. The iron is present in such cements in the state of celite, and belite is practically never found. The best ferrous cements have a high calcareous modulus CaO/SiO_2, which is near the theoretical maximum of 2.8, but they never contain uncombined lime. The synthetic products appear to be constituents of alite and celite which proves that alite is a tricalcium silicate free from alumina. The hydraulic characteristics of tricalcium silicate are not identical with those of Portland cement containing alumina so that the phenomena of setting and hardening seem to depend not only on tricalcium silicate but also on the aluminates present. Ferric oxide is a more active stabilizer of tricalcium silicate than alumina, although dicalcium ferrite is harmful to the hardening of tricalcium silicate when present above a certain amount (20%). The action of alumino-ferrous celite ($4CaO$, Al_2O_3, Fe_2O_3) which, according to researches made, plays an active part in the phenomena of setting and hardening of cements should be ascertained more exactly. M.V.K.

Notes on anhydrite. L. H. COLE AND R. A. ROGERS. *Can. Dept. Mines*, Invest. of Mineral Resources and the Mining Ind., No. 719, pp. 24–27 (1930).—The occurrences of anhydrite are described in detail and its uses are outlined. G.R.S.

Lowering water content in slurry with alkalis. M. PELET. *Rev. mat. constr. trav. pub.*, No. 265, pp. 407–408 (1931); *Pit & Quarry*, **23** [7], 82 (1932); for abstract see article by Budnikoff, Koukolev, and Lezhoew, *Ceram. Abs.*, **10** [1], 15 (1931). M.V.K.

PATENTS

Cement clinker treatment. H. M. LARMOUR AND S. C. PIERCE, JR. (Yosemite Portland Cement Corp.). U. S. 1,859,926, May 24, 1932. In the process of making Portland cement, the method of treating the hot clinker from the kiln comprises introducing to the hot clinker material selected from the group consisting of coke, coal, and oil, and cooling the mass while maintaining it substantially free from contact with oxygen.

Method of producing plaster of Paris, modeling plaster, etc. E. C. LOESCHE AND E. W. STOLL. Brit. 372,223, May 11, 1932.

Enamels

Microscopic technique in the investigation of enamel coating and some observations. G. W. MCGOHAN. *Jour. Amer. Ceram. Soc.*, **15** [7], 389–96 (1932).

Ascertaining the strength of enamel coats on iron objects. E. FRANKE. *Sprechsaal*, **65** [18], 328–29 (1932).—Defects in enamel coats may be caused by the nature of the metal and its surface to be enameled or by the chemical composition of the enamel itself. The brittleness of the enamel coat and the bursting of enamel particles depend on the composition of the enamel. During firing, tensions appear conditioned by the different coefficients of expansion of the separate constituents of the enamel mass. An incomplete mixing of the enamel may produce the same defects. Bubbles, which are often present in enamel coats, are due to an irregularity in the thickness of the enamel coat producing an uneven distribution of tensions. The bursting of the enamel particles is often caused by the defective shape of the object. The tensions appearing in such an object change with time or temperature and the enamel bursts. The bursting is also produced by an insufficient preparation of the surface of the metal; rust spots prevent the adhering of the enamel coat to the metal. The testing of the enamel can be mechanical, physical, or chemical. F. describes different mechanical methods for testing and points out their insufficiency. M.V.K.

Determination of boric acid in enamels. W. KERSTAN. *Keram. Rund.*, **38**, 393–94 (1930).—The rapid method of König and Spitz (*Z. angew. Chem.*, **9**, 551 (1896)) and the more exact method of Leonhardt and Zschimmer (*Sprechsaal*, **62**, 854 (1929)) are reviewed and are considered satisfactory for the determination of boric acid in enamels containing F. (*C.A.*)

Enameling cast iron. J. H. D. BRADSHAW. *Foundry Trade Jour.*, **46**, 162–65 (1932); see also *Ceram. Abs.*, **11** [2], 82 (1932). (*C.A.*)

Defects in cast enamels, their causes and prevention. III. WALTER KERSTAN AND OSKAR KERSTAN. *Emaillewaren-Ind.*, **9** [10], 71–75; [14], 107–109 (1932).—The purpose of the frit ground coat is to form an insulating layer between the iron and the enamel to prevent a reduction of the metallic oxides contained by the coating enamel by the carbon of the iron and to support the adhering layer. Cast frits should be of a simple (binary or ternary) composition with the usual additions to the mill. The frit ground must combine solidly with iron and therefore the layer of iron oxide must be of a definite composition. On heating the iron in an oxidized atmosphere, its surface oxidizes. Chemically, this layer is composed of a mixture of FeO and Fe_2O_3. The most desirable bonding layer must consist of ferrosoferric oxide. If oxidation or reduction appears during firing, the bonding oxide layer changes and the stability of the enamel is greatly affected. The firing of the ground must produce a solid solution of the FeO and Fe_2O_3 mixture, the so-called ferrosoferric oxide. The melting point of the ground enamel is regulated by additions to the mill; it must be suited to the nature of the iron, the firing temperature, and the firing time. The higher the muffle temperature, the more difficultly fusible the ground must be. The increase of the temperature interval is produced by increasing the mill additions of quartz or flint. A ground frit and its analysis are given and the importance of the mineralogical modification of quartz for the enameling is pointed out. Tables and diagrams showing the conversion reactions and the change in volume connected with it are given and explained. The formation of rust spots in the enamel is the most undesirable phenomenon. It may be caused by a low content in alkalis in the mass or by drying too slowly, which produces rust spots invisible to the naked eye and prevents the frit ground from adhering to the cast. The rust spots in casts are due to ferric sulphide precipitates and are greatly influenced by manganese which has an affinity to sulphur. The sulphide enrichments on the surface appear as brown spots after calcining. The importance of a careful cleaning of the cast before coating with the ground coat is emphasized. The firing temperature is between 850 and 880° according to the composition of the frit. For Part II see *Ceram. Abs.*, **11** [6], 346 (1932). M.V.K.

Dust. ANON. *Emaillewaren-Ind.* [Émail], **9** [18], 17–18 (1932).—Dust produces impurities in the enamel. It causes the appearance of bubbles in the interior and exterior enamel layers, and because of these bubbles, the tenacity and strength of the enamel are greatly lowered. During drying and firing, the dust penetrates into the

enamel and produces the same defects. It is supposed that organic dust is harmless but this is wrong as the dust ash remains in the enamel and the organic matter of the dust requires oxygen for burning at the expense of the enamel. When burning it produces gases which can not escape through the enamel but remain in it. Inorganic dust is also harmful, having a chemical influence on the enamel. M.V.K.

Gases in metals. C. J. SMITHELLS. *Metal Ind.* [London], **38** [10], 261–64 (1931).—All metals are capable of absorbing some gases under favorable conditions. In some cases the gas is absorbed by the molten metal and evolved on freezing while in others the solubility is high even in the solid state and large volumes of gas may be absorbed at ordinary temperatures. The laws governing the solubility of gases in ordinary liquids do not hold in the case of molten metals. In ordinary liquids, the solubility of a gas decreases as the temperature is raised, while with molten metals the solubility usually becomes greater at higher temperatures. The amount of gas that can be absorbed by a metal may be expressed volumetrically as the volume of gas at N.T.P. absorbed by 1 cu. cm. of metal, or by weight, *i.e.*, mg. of gas per mg. of metal, or cu. cm. per 100 g. Various methods of determination are used although they are essentially the same in principle. The solubility may be determined at constant temperature or at constant pressure. While most metals combine with oxygen to form solid oxides, silver, platinum, and palladium appear to absorb it as gas, and it can be recovered again by heating in a vacuum. Metals can be divided into the following rough classes with respect to their affinity for hydrogen: (1) Nickel, lead, iron, cobalt, and copper behave like palladium and form alloy systems. (2) Alkaline earth, alkali metals, and rare earth metals combine to form salt-like compounds (definite hydrides) and, although they are easily dissociated, the hydrogen is not present in the metal as gas. (3) Gold, silver, beryllium, and magnesium show practically no absorption. The solubility of hydrogen in various metals is shown in a table. A number of metals combine directly with nitrogen to form nitrides, *e.g.*, tantalum, calcium, chromium, and zirconium, but comparatively few absorb it as a gas. Nitrogen is insoluble in solid copper but slightly soluble in the molten metal, while silver, tin, antimony, and zinc show no measurable absorption. The usual method of determining the amount of gas present in a metal is to enclose the sample in a vessel which can be evacuated and then measure the volume of gas given off at various temperatures. M.V.K.

Gases in metals. PAUL D. MERICA. *Mining & Met.*, **12** [292], 189–91 (1931).—While it is generally conceded that gases in metals have certain known detrimental effects, it is not known in what other way the metals may be affected. A brief summary of the present knowledge of the subject is given. The chemical aspects of the problem are briefly discussed and the need for more basic data is stressed. E.J.V.

Occurrence and detection of gases in metals. JULIUS GRANT. *Metal Ind.* [London], **37** [13], 292 (1930).—G. discusses different methods used for the detection of gases in metals. M.V.K.

Control of the pickling bath. ANON. *Emaillewaren-Ind.*, **9** [17], 152–53 (1932).—The arrangements, manner of working, and the pickling pills or capsules used for the control of the pickling bath according to the method of Karl Türck are discussed. M.V.K.

Cleaning castings before enameling. ANON. *Emaillewaren-Ind.* [Émail], **9** [13], 13 (1932).—The results of tests on different sized steel particles and different air pressures are compared with those obtained by cleaning with acids. M.V.K.

Equipment for the cleaning of metal. XVII. R. W. MITCHELL. *Metal Cleaning & Finishing*, **4** [5], 273–76 (1932).—The cleaning of large metal parts by means of the steam gun is taken up. A description of various types of cleaning guns and their applications is given. Illustrated. For Part XVI see *Ceram. Abs.*, **11** [7], 404 (1932). E.J.V.

Manufacture of enameled containers from stamped sheet metal. W. GREINER. *Emaillewaren-Ind.*, **9** [18], 138–39 (1932).—G. describes the stamping of sheet-metal containers and their calcining, pickling, ground coating, firing, white spraying, cleaning, and firing. M.V.K.

Producing decorative effects in porcelain enameling. ANON. *Ceram. Ind.*, **18** [5], 300–303 (1932).—Marbleizing, graining, printing, and decalcomania are discussed in connection with the increased interest in art enameling. Methods of obtaining various effects are described. The four methods of art enamel application, cloisonné, champlevé, Limoges, and pointed enamels, are described, and formulas for clear, colorless enamel fluxes used in these processes are given. W.W.M.

Firing furnaces for the enamel industry and their efficiency. W. VÖLKEL. Abstracted from *Ind.-Gas*, No. 4, pp. 86–92 (1931); *Sprechsaal*, **65** [15], 277–78 (1932).—

V. discusses (1) the efficiency of electric furnaces, (2) muffle furnaces heated by gas, and (3) furnaces heated by coal. Data are given. M.V.K.

Variability of enamel during storing. ANON. *Emaillewaren-Ind.* [Émail], **9** [13], 11–12 (1932).—The fused enamel does not represent a definite and invariable product but changes its physical and chemical state during storing so that its general properties are always modified whether it is a liquid enamel or in a granulated form. It is recommended to introduce small quantities of calcium chloride into delicate enamels (majolica in powder) during their storing. M.V.K.

Enamel grinding practice. ANON. *Céram. verrerie*, **835**, 31–35 (1932); *Emaillewaren-Ind.*, **9** [14], 112 (1932).—The following subjects are discussed: equipment, cleaning of new linings, pebbles, charging and discharging of mills, speed of rotation of mills, duration of milling, control of milling, fineness of grind, and aging of the enamel. T.N.McV.

Calculating fuel consumption in enameling muffle kilns. VIELHABER. *Emaillewaren-Ind.*, **9** [13], 100–101 (1932). M.V.K.

Review of the latest developments of enameling. H. J. KARMAUS. *Emaillewaren-Ind.*, **9** [17], 131–32; [18], 140–42; [21], 161–64 (1932); for abstract see *Ceram. Abs.*, **11** [6], 350 (1932). M.V.K.

Making the monitor top refrigerator. GENERAL ELECTRIC CO. *Ceram. Ind.*, **18** [5], 285–92 (1932).—The modern and efficient refrigerator cabinet works of the General Electric Co. at Erie, Pa., is described in detail with numerous photographic illustrations. W.W.M.

PATENT

Continuous pickling apparatus. R. M. FENTON (Newton Steel Co.). U. S. 1,862,371, June 7, 1932.

Glass

Temperature coefficient of viscosity and its relation to some other properties of liquids and glasses. F. W. PRESTON. *Jour. Amer. Ceram. Soc.*, **15** [7], 365–77 (1932).

Analysis of glasses. F. FRANCESCHINI. *Ind. Silicati*, **10** [3], 7–10 (1932).—(*A*) The Qualitative Analysis. A rapid method for determining the constituents of glass is the microchemical analysis of Mylius and Graoscheff (*Sprechsaal*, No. 15 (1910)). (1) The glass is scratched with a file for a space of a few square millimeters. This surface is covered with a drop of ether of eosin iodide and then washed with a drop of ether. A more or less intense rose coloring indicates an alkaline glass, whereas a quartz glass remains perfectly white. (2) If, by pouring a drop of 10% HF on the glass, the surface becomes opaque, it is a sign that the glass is rich in earth oxides and heavy oxides (Ca, Pb, Zn, etc.). Glasses poor in metals show no opacity. (3) With the reaction product of (2) the colored flame test can be made with a platinum wire. A green flame indicates the presence of boric acid, yellow indicates sodium, and potassium is determined by a violet coloring by means of a cobalt blue glass. (4) A drop of a solution prepared by dissolving 0.1 g. sodium sulphate in 10 cc. of water and neutralizing with 1 to 3 drops HCl is added to the reaction product of (2). A black color gives lead (flint): in the presence of antimony, red-yellow is precipitated. The next test is made in a dish of the glass. Reaction (2) is repeated and continued for 5 min. The product obtained is placed in a platinum or porcelain crucible with 3 cc. of water, then mixed with 0.1 g. of bicarbonate of soda; a little residue still remains after the reaction, which is characterized by the formation of foam, is finished. It is then boiled till precipitation is complete, *i.e.*, until a drop of the liquid poured in a solution of methyl blue forms no precipitate. The precipitate is washed 3 times with 3 to 5 cc. of water and evaporated dry to 110° with the addition of 10 drops of dilute HCl. The residue treated with 3 cc. of water and 2 drops of dilute HCl gives the insoluble silica. It is filtered. In the filtrate, after the separation of lead and antimony by means of sulphurous acid, the following tests are made: (5) 1 drop of dilute H_2SO_4 is added to a part of the solution in a test tube; the formation of a heavy white precipitate indicates the presence of barium. (6) If, through the addition of a drop of a solution of ferrocyanide of potassium, a white viscous precipitate forms, zinc is present; a bluish color indicates that iron is present in very small quantities. (7) The refiltered solution of (6) is boiled with 3 drops of ammoniac solution; if alumina is present, white flaky aluminum hydroxide is pre-

cipitated. (Solution (6) containing zinc can be more easily cleared by the addition of some drops of a very dilute solution of silver nitrate, since the precipitate is more easily filtered.) (8) Solution (7) is again filtered and slowly heated after the addition of a drop of oxalic acid solution. After about 2 min. a white cloudiness appears caused by calcium. (9) Magnesium is determined by adding 2 drops of sodium phosphate solution to filtrate (8). A white precipitate is slowly formed. The determination of arsenic in glass and porcelain according to Laeckmann is as follows: A glass or porcelain dish is treated with 200 cc. of a binormal solution of sodium hydrate in a steam bath for 2 to 4 hr. or for $^1/_2$ hr. on a wire gauze over a direct flame but at a temperature below 100° (if only pieces can be had, they should be treated in a silver or platinum capsule). The sodium solution is then treated with a binormal solution of H_2SO_4 absolutely free from arsenic in an amount about $^3/_4$ of the solution; 3 cc. of a 1.4 normal solution of ferric ammonium sulphate is added and then the binormal H_2SO_4 till all the ferric hydroxide goes into solution (a small silica residue remains). After cooling with ice water, 3 to 3.5 cc. of 1.4 normal ammonia solution is added slowly, and the solution is continuously stirred until a light blue color is obtained with turnsole paper. With the ferric hydroxide separated, if arsenic is also present, the solution is filtered after 15 min. and dissolved on the filter itself with 30 to 40 cc. of a hot 3 normal H_2SO_4 solution. The volume is increased to 50 cc. with more of the same H_2SO_4 and arsenic is then determined with the Marsh-Liebig apparatus. All the reagents used must be entirely free from arsenic. (*B*) Quantitative Analysis According to Treadwell. Silica is determined by treating the product of calcination with sodium or potassium carbonate in HCl and drying; the residue is then heated to 115°. For the complete separation of silica, it is necessary to treat the filtrate of the first separation with HCl again, and to dry and reheat the residue to 115° as before. It is again treated with water and HCl, filtered, and the operation repeated on the filter. The silica is thus separated 3 times. In the filtrate in lead glasses, lead oxide is precipitated with sulphurous acid and the lead determined as lead sulphate. For the determination of the other bases (with the exception of the alkalis) the silica is eliminated from 0.5 to 1 g. of material in a second test by treating the glass with HF and H_2SO_4 and drying. The residue is treated with HCl. In the solution, the oxides of aluminum, iron, calcium, and magnesium are determined. A third test after the separation of silica with HF and H_2SO_4 serves to determine the alkalis according to the method of Berzelius or J. Lawrence Smith. The following methods of analysis are also given: "Standard method for the quantitative analysis of silicates," by Kall (see *Ceram. Abs.*, **5** [11], 375 (1926)); "Analysis of glasses rich in alumina," by Hiller (*ibid.*, **3** [10], 299 (1924)); The determination of silica according to Willard and Cake (*Jour. Amer. Chem. Soc.*, Vol. 42 (1920)); "Special reagent for determining antimony," by Feigl (*Z. anal. Chem.*, (1924)); "Analysis of zirconium glasses" (*Glass Ind.*, Vol. 7 (1926)); "Separation of iron and manganese," by Sanchez (*Bull. soc. chim. France*, Vol. 9 (1911)); "Separation and determination of calcium and magnesium," by Murmann (*Monatsh.*, No. 32 (1911)); "The determination of FeO in glasses isolating heat," by Heinrichs and Heumann (*Rept. Kaiser Wilhelm Inst. Silicate Researches*); "Qualitative test for FeO together with Fe_2O_3," by Tshugajev and Orelkin (*Z. anorg. allgem. Chem.*, pp. 401–404); "The valence of arsenic and antimony in glass," by Heinrichs and Salaquarda (*Ceram. Abs.*, **6** [6], 216 1927)); "The determination of As_2O_5 and As_2O_3 in glass according to Allen and Zies;" and "The rapid determination of boric acid in borosilicate glasses," by Werner Mylius (*Keram. Rund.*, No. 34 (1924)). M.V.K.

Rapid method for the analysis of glass. ANON. *Glashütte*, **62** [18], 301–302 (1932). M.V.K.

Chemical and physical analysis of glass. W. POPLAWSKI AND J. FABICKI. *Giorn. chim. ind. applicata*, **14** [3], 137 (1932); for abstract see *Ceram. Abs.*, **11** [6], 358 (1932). M.V.K.

Etching glassware. ANON. *Ceram. Ind.*, **18** [5], 304–307 (1932).—Etching glass by acid and sandblasting are discussed and some efficient practices are recommended. Methods of deep etching and mat etching are given with formulas for etching baths suitable for soda-lime and lead glasses. Various methods of applying resistant coatings are described. W.W.M.

Chemical processes appearing during silver etching. FR. SALAQUARDA. *Sprechsaal*, **65** [17], 310–13 (1932).—(1) The most important silver compounds were examined for their use in silver etching. The etching ability is not a function of the silver content of the composition but depends on the ease with which the latter is reduced. (2) The ability of the glass to take up or absorb a silver etching is increased by the presence of arsenic trioxide, ferrosoferric oxide, and antimony oxide. A highly mellowed glass

containing antimony oxide produces much stronger coloring than soft glasses. Manganous oxide increases the coloring also. Ceric oxide improves the development of color in borosilicate glasses and prevents it in soda-lime glasses. (3) Obtaining a good coloring with silver etching depends on the presence of reducing (coagulating) substances in the glass. (4) Another confirmation of the colloidal nature of silver yellow is found in the fact that the same sequence of colors was observed when using silver hydrosol or silver vitrosol. A table in colors showing the coloring of the surfaces of glasses depending on the silver composition, the firing time, and different glass constituents is given. M.V.K.

Yellow etching of glass. LUDWIG SPRINGER. *Sprechsaal*, **65** [19], 351–52 (1932).—S. discusses the researches of Heinrich (see *Ceram. Abs.*, **11** [4], 237 (1932)) on the yellow etching of glass, describes his own investigations, and compares the results. It was found that (1) glass containing 20% sodium takes up the yellow etching more than a glass with 20% potassium; (2) glass surfaces which have been heated more during firing or melting take up the yellow etching better because these surfaces are richer in alkalis. This fact shows that yellow etching may be used as indicator for the liquefaction of alkalis toward the surface. The application of bright gold on glass surfaces is discussed also. M.V.K.

Yellow etching. SCHATT. *Sprechsaal*, **65** [16], 294–95 (1932).—The yellow coloring of the glass results from the reduction of the silver salt. This reduction is affected by (1) the iron content or small impurities present in the glass, (2) the arsenic added to the batch, (3) colloidal carbon distributed in the glass, (4) flue gases during firing of the etching, and (5) additions to the etching paste. See also *Ceram. Abs.*, **11** [6], 355 (1932). M.V.K.

Notes on the decoloration of glass and new types of decolorants used in glass manufacture. F. FRANCESCHINI. *Ind. Silicati*, **10** [1], 7–10; [2], 7–10 (1932).—To obtain colorless glass, it is necessary to use decolorizers even with raw materials with a minimum iron content because the latter will inevitably show, especially in the thicker places, a slight discoloration depending on the degree of oxidation of the iron. Ferrous oxide shows bluish, ferric oxide, pale yellow, and a combination of both shows various nuances of green. The color that a glass of a definite composition assumes without the addition of a decolorizer is called the fundamental coloration. This coloration can either be reduced or transformed chemically. In this case the decoloration is based principally on the transformation of the deeper ferrous oxide coloring into the less noticeable ferric coloring. The fundamental coloration of a definite glass can not be learned from the analysis of the raw material. It may differ in the case of the same raw materials because of other factors, *viz.*, (1) the presence of oxidizing or reducing materials in the batch, (2) the type of flame, oxidizing or reducing, (3) the purity of the flame *i.e.*, the presence of ash or other combustion products, and (4) the fusion temperature. To determine scientifically what type or types of decolorizers to use, it is necessary to determine the absorption curve of a glass without decolorizers fused at the manufacturing plant in the ordinary glass-fusing kiln. If the specific action of each coloring oxide on the glass in question is known, it is possible to calculate which reducing oxides are to be added to the batch and in what quantities. Generally, however, the type and quantity of decolorizer is determined by experimenting with fusion samples. The following are the principal physical decolorants in the glass industry: (1) Nickel oxide colors potassium glass red-violet to reddish purple and sodium glass, yellowish red to red-brown. (2) Cobalt oxide gives glass a blue color. (3) Manganese colors glass from violet to violet-red. (4) Metallic selenium, soda selenite and selenate, and the respective potassium and barium salts color glass rose to red. (5) Of the rare earths, neodymium salts give a reddish color; didymium salts may also be used. The most important chemical decolorizers are arsenic, potassium and sodium nitrate, manganese, and cerium oxide. Manganese acts both as a chemical and physical decolorant. Chemical and physical decolorants are usually used together. Glasses decolorized with nickel oxide are more stable at high temperatures but absorb much light and are not brilliant. Cobalt oxide has a regular action and can also be used alone as a decolorant for glasses with a fundamental yellow color. Manganese is an uncertain decolorant as the degree of transformation of the coloring Mn_2O_3 into the noncoloring MnO depends on the firing, the presence of oxidizing and reducing agents, and the annealing temperature. Selenite, which is used more than metallic selenium, requires the presence of a little saltpeter for best results. It is used especially in tank kilns where there is a reducing atmosphere. Arsenic aids the decoloration with selenium. The longer the firing and the higher the temperature, the less coloring action selenium exerts. Selenium is used for the finest glasses and may also be used for lead crystal glass with

arsenic. The rare earths are not often used but best results are obtained for borosilicate glass. Decoloration with cerium dioxide has not been widely used in glass manufacture although its action is greatly superior to that of manganese. Various refiners, *e.g.*, saltpeter, sodium sulphate, and chloride, must be used with the cerium and excellent results are obtained. The quantity of decolorizer to use, the influence of the firing and annealing temperatures, and sunlight are discussed. The use of a combination of several decolorants in the glass batch and their composition are quoted from Späte. M.V.K.

Red fluorescence of glass. L. BRUNINGHOUS. Abstracted from *Jour. Phys. Radium*, **7** [2], 298–402 (1931); *Sprechsaal*, **65** [18], 332–33 (1932).—The researches of Lilienfeld, Gehrke and Reichenheimer, Wood, and Peters show that the red and green fluorescences observed in vacuum tubes are produced, respectively, by slow and rapid cathode rays. A longer action of slow cathode rays produces the disappearance of the red fluorescence in place of which green fluorescence appears. The process seems not to be reversible in the cold. Lilienfeld believes that the red fluorescence is due to the oxygen occluded in the glass. Wood explains it by chemical changes appearing in the glass effected by the presence of oxygen. Peters, on the other hand, explains it by the presence of crystalline surroundings in the silica group. B. discusses these theories in detail. The observations and theories of Urbain and Bruninghous are described according to which all fluorescent and phosphorescent substances represent a solid or liquid solution in which a material, the phosphogen, plays the active part in the emission of light. The phosphogen is present in a diluent whose purpose is to ensure a dissemination which is necessary to the molecule of phosphogen according to the law of optimum. On the basis of this assumption, B. concludes that the phenomenon depends on the presence of manganese even in very small quantities in the calcium silicate diluent of the phosphogen (lime salts always contain traces of manganese salts which fluoresce red or green). In the ordinary state, as in manganous compounds, a green fluorescence appears, but if the vacuum tubes are rinsed with oxygen, the manganous compounds are converted into manganic compounds which show a red fluorescence. With a long exposure to slow cathode rays, a gradual reduction appears due to the giving off of oxygen. Wood detected the lines of oxygen in the fluorescence spectrum. On the other hand, the rapid cathode rays affect the manganic compounds which are reduced producing the green fluorescence of the manganous compounds. M.V.K.

Efflorescences appearing on the glass surface during its annealing. SILBERT GUSS. Abstracted from *Glashütte*, **60** [51], 52 (1930); **61**, No. 1 (1931); *Ceramics & Glass*, **8** [2], 40–41 (1932).—G. discusses the researches of different investigators and describes his own on the appearance of efflorescences on the surface of glasses during annealing. Springer found that these efflorescences consist of alkaline metals (sulphates), some alumina, calcium, and undissolvable sand. Keppeler found that they are due to the action of tank gases, SO_2, CO_2, and H_2O (vapor) on the glass surface. G. concludes that the appearance of efflorescences is chiefly due to the action of SO_2 and CO_2. M.V.K.

White arsenic in the glass industry. P. M. TYLER AND A. V. PETERS. *Chem. Trade Jour.*, **90** [2345], 425–26 (1932).—Arsenious oxide takes up oxygen during the early stages of a melt and is a balancing agent in ensuring lack of color in the finished glass. Used in reasonable amounts in soda-lime glasses, its effects are beneficial except that the glass may turn yellow from solar radiation. Converting the ferrous ion into the ferric ion, arsenious oxide facilitates penetration of heat rays into the melt, resulting in higher furnace temperatures or in fuel economy. It facilitates fining in lead glasses but is objectionable where these must be subjected to subsequent heating as in the lamp work on tubing, which may darken it. The presence of arsenious acid in chemical glassware is undesirable. Its stirring action in glassmelting is doubtful and its influence as a flux is questionable. Arsenious or antimonious oxides are employed in selenium red glasses and the former is superior. The selenium red color is usually brought out with heat treatment. A number of arseno-sulphur compounds of selenium which range from light red to purplish black are known. Researches are now being made to determine whether these are formed in selenium red glasses, and whether the compounds may be utilized directly for the production of the color. M.V.K.

Manufacturing glass with sulphates from Crimea. S. V. RODIN. *Ceramics & Glass*, **8** [2], 20–21 (1932).—R. describes experiments made on manufacturing glass with sulphates from Lake Saki, Crimea. The glass mass was easily melted, had no bubbles, streaks, nor stones, and the glass obtained was of a greenish color. M.V.K.

Using substitutes for alkalis in glass manufacture. VOLOSEVITCH AND ZAGNIBORODOV. *Ceramics & Glass*, **8** [2], 21–22 (1932).—The authors describe experiments

made to manufacture glass in which the alkalis were replaced by the Khrompikowski sulphate, mirabilite, and volcanic ash. M.V.K.

Effect of alumina content of glass on the degree of corrosion of grog material of glass furnaces. P. P. BUDNIKOFF, G. V. KUKOLEV, AND I. S. SMELJANSKY. *Trans. Ukrainian Sci. Research Inst. Silicate Ind.*, Sci. Tech. Dept. Supreme Council Nat. Econ. [U.S.S.R.], Vol. XVI (1931); *Ukrainsky Silicaty*, **5** [11–12], 259 (1930); for abstract see *Ceram. Abs.*, **11** [2], 87 (1932). S.I.P.

Volatility of selenium and its compounds. OSZKÁR KNAPP. *Magyar Chem. Folyóirat*, **37**, 192–98 (1931); *Chem. Rund. Mitteleuropa u. Balkan*, **8**, 79–81 (1931).—Experiments with Se salts and preparations heated to 98 to 102° showed that the volatility varied over a very large range, depending on the quality of the salt. In the glass industry the best results were obtained with $BaSeO_3$. Pure Se, Na, and Zn selenites were more volatile. (*C.A.*)

Utilization of granite and syenite in the glass and ceramic industries. BARTIL GRANIGG. *Giorn. chim. ind. applicata*, **14** [3], 121–24 (1932); for abstract see *Ceram. Abs.*, **11** [6], 351 (1932). M.V.K.

Using semiconductor photocells in glass technical laboratory. B. LANGE. *Sprechsaal*, **65** [14], 255–56; [15], 275–77; [16], 293–94 (1932).—L. describes in detail a new apparatus which can be used for simple photometric measurements, spectrum photometric measurements, reflection, and colorimetric measurements. See also *Ceram. Abs.*, **11** [4], 231 (1932). M.V.K.

Effect of anion of raw material on the properties of glass. K. NAKANISHI. *Jour. Soc. Chem. Ind.* [Japan], **35** [4], 172–74*B* (1932).—Soda-lime or soda-lime-lead glasses prepared from $Ca(OH)_2$ or CaO have a greater coefficient of expansion and hardness than those prepared from $CaCO_3$ batches. In a previous report N. observed that the specific gravity of glasses prepared from $CaCO_3$ batches was higher than that of glasses prepared from $Ca(OH)_2$ or CaO. Further, glasses from $Ca(OH)_2$ or CaO batches froth more than those from $CaCO_3$ batches when heated to very high temperatures or heated in a gas flame. Glasses prepared from calcium hydroxide or calcium oxide batches, therefore, contain more gasses than those from calcium carbonate batches. M.V.K.

Dielectric constants of glasses of different composition. F. KELLER. *Z. tech. Physik*, **13** [5], 237–39 (1932).—The melts were made in large pots, the composition being 82% SiO_2 + metallic oxide and 18% Na_2O; SiO_2 was replaced by MgO, CaO, ZnO, BaO, PbO, B_2O_3, Al_2O_3, and Fe_2O_3. Besides these, glasses were investigated containing 80% SiO_2 + alkalis and 20% PbO, SiO_2 being replaced by K_2O and Na_2O, respectively, and 65% SiO_2 15% K_2O + Na_2O 20% PbO, K_2O being replaced by Na_2O. Glass plates were made and two opposite surfaces silvered. The capacity of the condenser thus formed was measured. The dielectric constant increases when replacing SiO_2 by Na_2O, K_2O, CaO, BaO, PbO, MgO, ZnO, B_2O_3, Al_2O_3, and Fe_2O_3. W.M.C.

Relation of temperature to the modulus of glass rods. K. H. HEINZ MULLER. *Z. Physik*, **69** [7–8], 431–55 (1931).—A more exact knowledge of the relation of temperature to the tearing strength of glasses is of interest for the verification of the Griffith "Bruch theory." In tearing glass rods by tension the break is characterized by two different surface formations: a mirror-smooth oval part known as the "Spiegel" and an uneven part consisting of lines radiating from the "Spiegel." The strength of the rods is determined by two different material constants: (*a*) the lower tearing limit Z_μ in cases where there is a complete "Spiegel" formation, and (*b*) the upper tearing limit Z_o which can be calculated for moderate mirror formation (5 to 40% of the cross-section of the rod) in a simple manner from the usual tensile strength. The dependence of the size of the mirror and Z_o on the cross-section, the previous treatment of the glass, and the temperature were studied on six glasses. When the break is a complete "Spiegel," as in the case of scratched rods or at high temperatures, tearing occurs at the minimum strength, Z_μ. This is the true limit of safety of glass rods on tension. Z_o in rods from 0.4 to 4 mm.² varies and depends on the previous treatment of the glass. It decreases on long aging. Z_o varies between −60 and +105°C with cross-section. On increasing temperature, Z_o remains unaltered or decreases depending on the composition. The more the elasticity modulus varies with the temperature, the greater is the dependence of Z_o on the temperature. The temperature coefficent of Z_o is greater than that of the elasticity modulus. This seems to contradict the Griffith theory but shows that the theory holds only for the lower limit Z_μ. By Griffith's theory the relation

$$S = \sqrt{\frac{4\sigma E}{\pi\lambda}}$$

holds for the smallest value of the tensile strength, S, of a level plate with a straight scratch of length, λ, where σ is surface energy and E the elasticity modulus. L.T.B.

Causes of thermal nonstability of bottles; investigation of the leers of the state bottle works at Konstantinovka. G. V. KUKOLEV. *Trans. Ukrainian Sci. Research Inst. Silicate Ind.*, Sci. Tech. Dept., Supreme Council Nat. Econ. [U.S.S.R.], Vol. XVI (1931).—The method adopted for investigation, the results of testing, and conclusions are outlined. S.I.P.

Influence of thermal treatment on the exactness of thermometers. E. A. KHVAS. *Ceramics & Glass*, **8** [2], 17–20 (1932).—C. discusses the physical and chemical processes taking place in thermometer glass while it is being worked over a blast burner. After a discussion of the present literature on this question, K. concludes that the inexact work of thermometers is due to the action of capillary forces and thermal phenomena in the glass during working. M.V.K.

New method of melting glasses and silicates. G. A. ZOTOS. *Pottery Gas.*, **57** [659], 645 (1932).—The characteristic feature of the new melting process was the peculiar construction of the combustion chamber, in which, although much higher temperatures were possible, the furnace fabric was protected. All surfaces, in particular the passive heat-losing surfaces, were replaced by active heat-receiving surfaces which effected a sudden rise in the furnace efficiency. E.J.V.

Technique of modern artistic window glass. PIETRO CHIESA. *Ind. Silicati*, **10** [2], 11–12 (1932).—The technique of the medieval glassmakers is now well known and it is no longer possible to speak of the secrets of the ancients. In the 14th Century, the window glassmakers traveled about the country with a load of glass and their tools, stopping wherever work was found. Their first step was to build the kiln. Next, after the window was designed, the pieces of different colored glass were cut out and painted with a certain black paint that they made by grinding fine yellow Venetian glass and copper to indicate the shadows and folds in the garments and to model the flesh and trace the ornamentation. The pieces were then placed on iron plates and fired. Well seasoned poplar was used for fuel. The glassmaker regulated the heat by observing the color of the glass through a peephole in the kiln. When the firing was finished, the fire was removed and the kiln sealed up till completely cooled. The pieces of glass were then fastened together with lead and strips of metal and soldered with tin. Now, however, not only have working conditions and material entirely changed, but also the technique and methods of interpretation of the artist. In England a transparent enamel was tried instead of colored glass (Masilloc and Jean Coussin). In France Janin replaced window glass by crystal cut by a sand jet, and Leon Barillet adopted glasses of contrasting structure. In Germany Poul and Wagner recently exhibited window panes fastened with lead and executed in glass of two layers of different colors, one opaque and the other enameled. In Italy Picchiarini created a kind of transparent glassy mosaic of rich coloring for windows. Lerche attempted making a type of window glass similar to the American Tiffany. Zecchin tried to cast a colored window in a single pane, but because it was made up of pieces of different dilatation it was very fragile. M.V.K.

Scratching of plate glass. G. TAMMANN AND H. E. VON GRONOW. *Z. anorg. allgem. Chem.*, **201** [1-2], 37–40 (1931).—Polishing of glass must be done with materials which are harder than glass itself. To avoid fractures and scratches the polishing water is usually replaced by turpentine. This indicates that there is a dependence of the type of scratch on the polishing liquid. To study this, a diamond point under constant load but with various liquids on the glass was drawn over the glass plate. Six classes of scratches were observed microscopically, based on the type of fracture along the scratch. With increasing load on the diamond the depth and width of the fractures increased. The greatest protection against fracture was offered by turpentine oils, and the least protection by air. There is no plastic deformation when the point passes over the glass, or a round edge would be formed along the scratch instead of the sharp edge or the conchoidal fractured edge. L.T.B.

Manufacture of optical glass. C. J. PEDDLE. *Trans. Optical Soc.* [London], **23** [2], 103–30 (1931); *Glastech. Ber.*, **10** [1], 49 (1932).—P. added definite percentages and molecular proportions of the MgO, ZnO, CaO, SrO, BeO, and PbO oxides to the raw mixtures $100SiO_2{\cdot}20Na_2O$, $100SiO_2{\cdot}20K_2O$, $100SiO_2{\cdot}40Na_2O$, $100SiO_2{\cdot}40K_2O$, and investigated the effect of these oxides on density, refractive index, chromatism, and inclination to devitrification. M.V.K.

Manufacturing pane and mirror glass by the Fourcault method. L. K. KOVALEV. *Ceramics & Glass*, **8** [2], 11–15 (1932).—A detailed discussion of the Fourcault machines and of producing pane and mirror glass on these machines is presented. M.V.K.

Manufacture and cost of production of safety glass. FRITZ OHL. *Sprechsaal*, **65** [20], 369 (1932).—The manufacture of safety glass, its cost of production, and consumption in Germany are given. M.V.K.

New safety glass. ANON. *Sprechsaal*, **65** [16], 304 (1932).—The new "Armorplate" safety glass manufactured in Canada is described. The specific properties of this glass are as follows: (1) it does not decolorize even after long service; (2) it withstands high temperature variations; (3) it is highly resistant to the influence of cold; and (4) its coefficient of bending is from 3 to 4 times higher than that of ordinary glass. M.V.K.

Glass wool in air filters. OWENS-ILLINOIS GLASS CO. *Ceram. Ind.*, **18** [5], 295 (1932); for abstract see *Ceram. Abs.*, **11** [7], 424 (1932). W.W.M.

Testing of ampoule glass. E. UBRIG. *Pharm. Ztg.*, **77**, 227–28 (1932).—The glass is pulverized and the particles are graded by sieving. Washing with cold H_2O removes surface contaminants due to dirt present before blowing. Traces of acid due to HCl washing and alkali dissolved on autoclaving the glass in the presence of H_2O are subsequently detected by the use of a "universal" indicator. See also *Ceram. Abs.*, **11** [2], 95 (1932). (*B.C.A.*)

Cold and hot methods of cutting glass. M. S. KAZANSKI AND V. V. VITSHAS. *Ceramics & Glass*, **8** [2], 16–17 (1932).—The advantages and disadvantages of both cold and hot cutting of glass are discussed. The advantages of the former method are (1) increased output and improved quality of the glass, (2) increased efficiency of labor, and (3) improved working conditions. M.V.K.

Experiments in melting bottle glass in a flowing tank kiln. SILBERT GUSS. *Glashütte*, **62** [4], 57–58; [5], 73–74; [7], 105–107; [9], 150–54; [10], 165–66 (1932).—Melting bottle glass in a modern recuperative flowing tank kiln with a U flame is described in detail. The glass obtained is of good quality. M.V.K.

Recent developments in open-hearth furnace design. R. A. HACKING. *Pottery Gaz.*, **57** [659], 644–45 (1932).—The striking analogies existing between the melting of steel and the melting of glass were pointed out. The development from the pot method to the present large capacity furnaces was traced. Greater outputs are being facilitated through the provision of perfect combustion by automatic means. Most of the limitations placed upon furnace design can be classed under the heading of the need for better refractories. E.J.V.

Possibilities in the development of glassmelting tanks. W. FRIEDMANN. Abstracted from *Glastech. Ber.*, **9** [10], 551–58 (1931); *Feuerfest*, **7** [11], 173 (1931).—F. discusses (1) the means of removing the fundamental defects present in glassmelting installations, (2) defects in the tank constructions, (3) shaft tanks of Künzel and Fergusson, (4) rotary tanks of Zotos, (5) tanks with oblique melting surface of Frinke, (6) separation of melts and working according to Schneider, and (7) suggestions of Opperman. M.V.K.

New burner for tank furnaces. HERMANN PASSAUER. *Sprechsaal*, **65** [17], 313–15 (1932).—P. discusses the defects of burners used in glassmelting tanks and describes a new burner which distributes the heat uniformly. The burner permits (1) a regulation of the flame while the fire is neutral without waste of fuel, (2) changes in the composition of gases, and (3) changes in the fuel used. The advantages from an economical point of view are (1) increase in production, (2) considerable economy in fuel, (3) better and more uniform glass color, and (4) improvement of the quality of glass. M.V.K.

Protective coat for glassmelting pots. SHUR AND VASSILIEV. *Ceramics & Glass*, **8** [2], 26–27 (1932).—The protective coat consisted of 94% refractory clays from Chassov-Yar and 6% of finely ground feldspar. The thickness of the coat was from 2 to 8 mm. The pots were fired for 3 days to 1000°, then used for melting white enamel. The pots withstood about 5 melts on the average. See also *Ceram. Abs.*, **11** [5], 300 (1932). M.V.K.

Progress in the glass industry in 1931. ANON. *Glashütte*, **62** [17], 283–84 (1932).—In contradiction to the theory that glass is a fourth state of matter, Salmang and Koerner (see *Ceram. Abs.*, **11** [2], 86 (1932)) found that the sudden changes of the physical properties of glasses on heating and cooling appear only under certain conditions and therefore the separation of the liquid-plastic and plastic-brittle state and the fixing of transformation and aggregation points are not acceptable. When glasses free from tensions are slowly heated, no change in the direction of the expansion curve appears. The authors assume that a sudden change of the coefficients of expansion in rapidly heated glasses is effected by a sudden adjusting of tensions. The transformation points appearing with rapid heating can not be considered as transformation points; transformation points appear in crystals even with a very slow heating rate. The following researches are also discussed: (1) the devitrification of glass by Preston

(*ibid.*, **10** [4], 259 (1931)); (2) influence of devitrification constants by Müllensiefen and Zschimmer (*ibid.*, **11** [7], 405 (1932)); (3) devitrification products of technical soda-lime-silica glasses by Dietzel (*ibid.*, **11** [7], 407 (1932)); (4) density of soda water glass by Turner and Winks (*ibid.*, **10** [10], 685 (1931)); (5) influence of glass manufacture and working on its brittleness by Russ (*Glastech. Ber.*, **9**, 481 (1931)); (6) strength of glasses free from tensions by Knapp (*Ceram. Abs.*, **11** [7], 404 (1932)); (7) stresses in wire-glass due to the wire by Preston (*ibid.*, **10** [7], 485 (1931)). M.V.K.

Standardization of laboratory glass in Czechoslovakia. J. JELINEK. *Giorn. chim. ind. applicata*, **14** [4], 198 (1932).—Standards for the exact dimensions of glassware used in chemistry and in manufacturing plants have been published by the Czechoslovakian Society for Standardization. M.V.K.

Ekeberga-Kosta glass factory in Sweden. M. VON REIBOLDT. *Sprechsaal*, **65** [20], 369–70 (1932).—B. describes in detail the Ekeberga-Kosta glass factory, raw materials, methods used, etching, polishing, painting, and engraving. M.V.K.

BOOKS

Technical and Scientific Transactions of the Osram-Konzern. (Technisch-wissenschaftliche Abhandlungen aus dem Osram-Konzern.) ANON. 2 volumes. Julius Springer, Berlin, 1930 and 1931. Reviewed in *Sprechsaal*, **65** [16], 304 (1932).—These volumes contain a compilation of researches carried out by the Osram Corporation and include (1) "The physical properties of glasses in dependence on their composition," by Gehlhoff and Thomas; (2) "Researches on the dependence of the relative water attack of the glass on its chemical composition," by Enss; (3) "Electric conductivity of glasses," by Fulda; (4) "Storing and packing of glassware," by Gehlhoff and Schmidt; (5) "Light absorbtion of opal glass," by Gehlhoff and Thomas; (6) "Experimental studies of the optical properties of strongly opacified media," by Lax, Pirani, and Schönborn; (7) "Physical properties of glasses in dependence on their composition. IV," by Fritz-Schmidt, Gehlhoff, and Thomas (*Ceram. Abs.*, **10** [4], 257; [12], 829 (1931)); (8) "Heat conductivity of glasses in dependence on their chemical composition," by Russ; (9) "Purifying glass," by Gehlhoff, Kalsing, and Thomas (*ibid.*, **9** [8], 625 (1930)); (10) "Influence of the thermal treatment on the viscosity of glasses," by Gehlhoff and Thomas (*ibid.*, **10** [6], 413 (1931)); (11) "Processes appearing during chemical grinding of glasses," by Fenske and Koref (*ibid.*, **11** [6], 355 (1932)); (12) "Critical researches on methods for determining the power of attack on glasses," by Rexer (*ibid.*, **10** [7], 486 (1931)); (13) "Qualitative and quantitative determination of gas content in glass bubbles," by Enss (*ibid.*, **9** [8], 625 (1930)); (14) "A method for measuring the gray content and the color tinge of glasses," by Russ and Thomas (*ibid.*, **9** [5], 327 (1930)); (15) "Properties of refractory clays for the glass industry," by Gehlhoff, Kalsing, Litzow, and Thomas; (16) "Influence of the distribution of grains of grog on the density of refractory materials," by Litzow (*ibid.*, **10** [5], 354; [9], 645 (1931)); (17) "Thermal conductivity measurements on refractory materials," by Fritz-Schmidt and Gehlhoff (*ibid.*, **10** [6], 433; [7], 507 (1931)); and (18) "Methods for determining thermal conductivity of powdered bodies at high temperatures," by Pirani and Wangenheim (*ibid.*, **10** [6], 431; [8], 587 (1931)). M.V.K.

Technique of Glass Ornaments. (Die Technik des Glaschmuckes.) WILHELM HANNIG. Max Jänecke, Leipzig, 1931. 7.30 Rm. Reviewed in *Sprechsaal*, **65** [16], 304 (1932).—J. discusses the working of glass into ornaments, polishing, pressing, etching, sand grinding, painting, and enameling with special consideration for the production of pearls. M.V.K.

Course in Glassmaking: Physical and Thermal Properties of Glass. Vol. II. (Cours de verrerie: Physique thermique du verre.) EMILIO DAMOURS. Charles Beranger, Paris. 211 pp. 67 illustrations. 55 F. Reviewed in *Rev. mat. constr. trav. pub.*, No. 271, pp. 79–80*B* (1932).—The first volume of the course in glassmaking treated the chemistry of glass, *i.e.*, composition, chemical analysis, and influence of constituents on the principal properties of industrial glass. The second volume treats the physical properties of glass, *i.e.*, fusion, annealing, resistance, elasticity, hardness, permeability, electrical and thermal conductivity, optical properties, etc.; a detailed study of glassmelting kilns and their operation and construction is given. The last part of the course discusses pottery and the manufacture of refractory materials used in the glass industry. For Vol. I see *Ceram. Abs.*, **9** [6], 422 (1930). M.V.K.

Use of electrochemical by-products in glassmaking. I. Arsenic, selenium, and tellurium. ALEXANDER SILVERMAN. *Trans. Electrochem. Soc.*, **61** (preprint), 12 pp. (1932).—As_2O_3 takes O during the early stages of a melt and is a balancing agent in

insuring lack of color in the finished glass. In soda-lime glasses, its effects are beneficial except that glasses may turn yellow under solar radiation. Converting Fe^{++} to Fe^{+++}, As_2O_3 facilitates penetration of heat rays into the melt, resulting in higher furnace temperatures or in fuel economy. It facilitates fining in Pb glasses, but is objectionable where these must be subjected to subsequent heating. The presence of As_2O_3 in chemical glassware is undesirable. Its stirring action in glassmelting is doubtful. Its influence as a flux is questionable. From 0.5 to 1.0% Se is employed extensively in the manufacture of red Zn glasses under reducing conditions. Less Se is required for the desired color in K glasses than in Na glasses. Se apparently is as effective in color production as the selenites and is less expensive on the basis of equivalent weights. CdS is employed with Se in practically all the desirable red glasses. C or S is usually employed as a reducing agent in Se red glasses. As_2O_3 or Sb_2O_3 is employed in Se red glasses, and the former is superior. The Se red color is usually brought out under heat treatment. Under oxidizing conditions in lime glasses containing K and practically free from Fe, Se produces a pink color. In Na-Ca glasses, Se produces an orange color in the presence of a reducing agent. In Pb glasses, Se produces an amber color in the presence of niter. Se is effectively employed in low concentrations as a decolorizing agent, especially for Na-Ca glasses. As_2O_3 serves as a control. No commercial applications of Te have as yet been made. See also *Ceram. Abs.*, **10** [7], 488 (1931). (*C.A.*)

Book Review

The Works of the Central Laboratory of the Ukrainian Refractory Cement Trust for the Years 1928 to 1930. Under the direction of P. P. BUDNIKOFF. Published by the Supreme Council of Public Economy [U.S.S.R.], Kharkov, 1932. 274 pp. Free. This book deals with silicate raw materials, finished products, and research works. The last part includes the following articles: (1) liquefying of refractory clays, (2) casting blocks for glassmelting furnaces, (3) manufacture of refractory materials free of grog, (4) manufacture of refractory materials from semidry masses, (5) the influence of kaolin additions to the batch on the properties of refractories, (6) manufacture of light-weight refractory brick, (7) manufacture of channel brick used for casting steel, and (8) how to lower the price and increase the quality of slag Portland cements. Many of these papers have already been published in the silicate journals. In this book all the articles are systematized and some additional data are given. The book concludes with a description of some common and rapid methods of testing silicate materials.

S. I. PERKAL

PATENTS

Take-out mechanism for glass-forming machines. J. W. ROSS (Hazel-Atlas Glass Co.). U. S. 1,858,642, May 17, 1932.

Method and apparatus for making glass articles. CHARLES WALES (Western Electric Co.). U. S. 1,859,011, May 17, 1932.

Glassware-forming machine. H. A. ROHRICH (Owens-Illinois Glass Co.). U. S. 1,859,053, May 17, 1932.

Glassware-forming apparatus. A. N. CRAMER (Owens-Illinois Glass Co.). U. S. 1,859,074, May 17, 1932.

Glassblowing machine. L. D. SOUBIER (Owens-Illinois Glass Co.). U. S. 1,859,113, May 17, 1932.

Means for making blown-glass articles. L. D. SOUBIER (Owens-Illinois Glass Co.). U. S. 1,859,114, May 17, 1932.

Manufacture of hollow glassware. R. W. CANFIELD (Hartford-Empire Co.). U. S. 1,859,230, May 17, 1932.

Glassware-making apparatus. R. W. CANFIELD (Hartford-Empire Co.). U. S. 1,859,231, May 17, 1932.

Glass-forming apparatus. R. W. CANFIELD (Hartford-Empire Co.). U. S. 1,859,232, May 17, 1932.

Continuously operating glassware-forming machine. R. W. CANFIELD (Hartford-Empire Co.). U. S. 1,859,233, May 17, 1932.

Continuous two-table glassware-forming machine. R. W. CANFIELD (Hartford-Empire Co.). U. S. 1,859,234, May 17, 1932.

Method and apparatus for forming glassware. R. W. CANFIELD (Hartford-Empire Co.). U. S. 1,859,235, May 17, 1932.

Apparatus for producing hollow glassware. L. D. Soubier (Owens-Illinois Glass Co.). U. S. 1,859,247, May 17, 1932.

Process and apparatus for making sheet glass. Louis Boudin (Soc. anon. des manufactures des glaces et produits chimiques de St.-Gobain, Chauny, et Cirey). U. S. 1,859,862, May 24, 1932. J. L. Drake (Libbey-Owens-Ford Glass Co.). U. S. 1,860,082, 1,860,085, and 1,860,140, May 24, 1932.

Apparatus for forming reinforced glass. Karl Macht (Schlesische Spiegelglas Manufactur Carl Tielsch, G.m.b.H.). U. S. 1,859,880, May 24, 1932.

Leer. Vergil Mulholland (Hartford-Empire Co.). U. S. 1,859,931, May 24, 1932.

Elevating take-out. R. W. Canfield (Hartford-Empire Co.). U. S. 1,859,956, May 24, 1932.

Rolling process for glassware. R. W. Canfield (Hartford-Empire Co.). U. S. 1,859,957, May 24, 1932.

Sheet-glass apparatus. L. C. Mambourg (Libbey-Owens-Ford Glass Co.). U. S. 1,860,044, May 24, 1932. F. J. Kincaid (Libbey-Owens-Ford Glass Co.). U. S. 1,860,100, May 24, 1932.

Furnace. Nestor Mambourg (Libbey-Owens-Ford Glass Co.). U. S. 1,860,045, May 24, 1932.

Apparatus for producing laminated glass. Daniel Adams (Libbey-Owens-Ford Glass Co.). U. S. 1,860,067, May 24, 1932.

System for surfacing glass sheets. J. L. Drake (Libbey-Owens-Ford Glass Co.). U. S. 1,860,083, May 24, 1932.

Car-window construction. J. L. Drake (Libbey-Owens-Ford Glass Co.). U. S. 1,860,084, May 24, 1932.

Apparatus for making plate glass. J. H. Fox (Pittsburgh Plate Glass Co.). U. S. 1,861,627, June 7, 1932.

Roller runway for sheet glass. William Owen (Pittsburgh Plate Glass Co.). U. S. 1,861,665, June 7, 1932.

Method and apparatus for drawing glass. A. E. Spinasse (Pittsburgh Plate Glass Co.). U. S. 1,861,761, June 7, 1932.

Safety glass. Max Hagedorn and Adolf Jung (I. G. Farbenindustrie Akt.-Ges.). U. S. 1,861,915, June 7, 1932.

Glass-crumbling machine. J. J. McCabe (Bausch & Lomb Optical Co.). U. S. 1,862,194, June 7, 1932.

Machine for the manufacture of hollow blown-glass articles. R. F. Hall. U. S. 1,862,264, June 7, 1932.

Method and apparatus for fusing silica, etc. P. K. Devers (General Electric Co.). U. S. 1,862,358, June 7, 1932.

Marking quartz. Sylvester Boyer (General Electric Co.). U. S. 1,862,366, June 7, 1932.

Continuous glass grinding and polishing apparatus. F. B. Waldron (Pilkington Bros., Ltd.). U. S. 1,862,445, June 7, 1932.

Glass road blocks. G. J. Ricketts. Brit. 371,507, May 4, 1932.

Mechanisms for feeding articles into leers. J. E. Pollak (Hazel-Atlas Glass Co.). Brit. 372,106, May 11, 1932.

Manufacture of unsplinterable glass. T. C. Redfern, J. F. W. Stuart, T. W. Holt, and Aeroplex, Ltd. Brit. 372,219, May 11, 1932. I. G. Farbenindustrie Akt.-Ges. Brit. 372,579, May 19, 1932.

Joints for quartz tubes, etc. Jenaer Glaswerk Schott & Gen. Brit. 372,946, May 25, 1932.

Laminated glass. George B. Watkins (Libbey-Owens-Ford Glass Co.). Can. 320,840, March 22, 1932. Between 2 or more sheets of glass is interposed a cellulose composition treated with a mixture of monoethyl ether of diethylene glycol 40, monobutyl ether of diethylene glycol 30, and dibutyl phthalate 30%. See also *Ceram. Abs.*, **11** [4], 242 (1932). (*C.A.*)

Safety glass. George B. Watkins (Libbey-Owens-Ford Glass Co.). Can. 320,841, March 22, 1932. A mixture of gelatin and diethylene glycol in the ratio of 4:56 is made to react in the presence of a small quantity of salt, *e.g.*, $CaCl_2$, $BaCl_2$, $MnCl_2$, and 40 parts of H_2O are added. The solution is deposited on one surface each of two sheets of glass, a nonbrittle layer, *e.g.*, pyroxylin plastic sheet, is interposed between the sheets, and the glass is then subjected to heat and pressure. (*C.A.*)

Cooling furnace for sheets of glass. N.-V. Maatschappij tot Beheer en Exploitatie van Octrooien. Fr. 717,854, May 28, 1931. (*C.A.*)

Device for withdrawing or delivering measured quantities of fused glass. ADOLF SCHILLER. Ger. 518,236, July 29, 1926. (*C.A.*)

Device for withdrawing and delivering measured quantities of molten glass. JOSEPH SCHÄFERS. Ger. 543,048, Jan. 5, 1929. (*C.A.*)

Glass. JENAER GLASWERK SCHOTT & GEN. Ger. 541,554, March 22, 1923. A difficultly fusible glass which can withstand abrupt temperature changes, contains at least SiO_2 45, B_2O_3 2 to 15, MgO plus CaO (or NaO and ZnO) 4 to 30, Al_2O_3 20 to 30, and alkali oxide up to 8%. Examples are given. (*C.A.*)

Rolling thin plate glass. COMPAGNIES RÉUNIES DES GLACES ET VERRES SPÉCIAUX DU NORD DE LA FRANCE. Ger. 541,645, Aug. 17, 1928. (*C.A.*)

Tank furnace for glass manufacture. HARTFORD-EMPIRE CO. Ger. 543,046, Dec. 5, 1929. (*C.A.*)

Apparatus for delivering measured batches of molten glass. DEUTSCHER VERBAND DER FLASCHENFABRIKEN G. M. B. H. Ger. 543,047, June 3, 1930, and 543,094, Aug. 16, 1916. (*C.A.*)

Glass. SOC. ANON. DES MANUFACTURES DES GLACES ET PRODUITS CHIMIQUES DE ST.-GOBAIN, CHAUNY, ET CIREY. Ger. 543,095, Jan. 12, 1927. Up to 2% of TiO_2 is added to glass consisting mainly of CaO, SiO_2, and alkali and containing small amounts of oxides, such as Fe_2O_3 and MnO, which normally cause the glass to become colored on prolonged exposure to sunlight or light of short wave-length. The addition of TiO_2 inhibits the coloration. (*C.A.*)

Apparatus for drawing glass strips, tubes, or rods. DEUTSCHE LIBBEY-OWENS-GES. FÜR MASCHINELLE GLASHERSTELLUNG A.-G. Ger. 543,301, Aug. 26, 1930. (*C.A.*)

Continuous apparatus for drawing glass tubes or rods. N.-V. MAATSCHAPPIJ TOT EXPLOITATIE VAN UITVINDINGEN. Ger. 543,302, Sept. 4, 1930. (*C.A.*)

Silver mirrors. STEFAN GOLDSCHMIDT AND ERICH LITTMANN. Ger. 544,415, Aug. 3, 1929. In depositing Ag on glass, etc., by reduction processes, the parts on which a deposit is not required are coated with a thin layer of difficultly soluble metal hydroxides or basic salts. Hydroxides or basic salts of Al, Mn, Cu, Bi, Pb, Sn, and Hg are suitable. Details and examples are given. (*C.A.*)

Structural Clay Products

Efflorescences in ceramic products. JOSEF MATĚJKA. Abstracted from *Slavivo*, p. 317 (1931); *Rev. mat. constr. trav. pub.*, No. 271, p. 77*B* (1932).—M. points out that the quantity of soluble salts considerably varies according to the water permeability, *i.e.*, the quantity of SO_3 in the objects varies greatly, although for other constituents the composition of the mix remains uniform. Efflorescence is often produced by the amount of humidity because the water absorbs SO_3 when passing through the clay layers. In previous researches, M. emphasized the importance of aging; it was found that after a year's rest, the quantity of SO_3 soluble in the mass increased from 0.024 to 0.076%. It is known that the greater part of the soluble salts is due to the decomposition of pyrites present in coal, and the intensity of the decomposition of soluble salts during firing is greater the higher the firing temperature, *e.g.*, aluminum sulphate and iron sulphate decompose at 650°, magnesium sulphate at 900 to 1000°, and sulphate of lime at over 1200°. M. found that earths containing lime react with smoke more than earths without lime, and that efflorescences may be avoided by rapid drying. M.V.K.

Soluble salts in masonry. W. DAWIHL. *Tonind.-Ztg.*, **56** [33], 434–35 (1932).—Potassium sulphate on one hand and sodium and magnesium sulphates on the other hand, will give a number of different compounds. The influence of the vapor pressure of some salts is discussed in connection with the moisture content of the air. W.M.C.

Hollow-tile masonry treated by the rainfall test. ANON. *Tonind.-Ztg.*, **56** [36], 471 (1932).—The masonry was placed under a shower for from 3 to 27 hours. No trace of moisture was found on the back side of the brick. W.M.C.

Special products of the brick industry. E. WINKLER. *Tonind.-Ztg.*, **56** [33], 436–37 (1932).—This paper deals with the drying and firing of hollow tile. See also *Ceram. Abs.*, **11** [7], 421 (1932). W.M.C.

Stiff-plastic brickmaking; a new system. JOHN PROCTER. *Brit. Clayworker*, **41** [481], 52–54 (1932).—Preparation begins by adding water in a horizontal mixer from which the batch goes to a machine consisting of two perforated drums set parallel to each other and inclined. The dampened shale is squeezed through the perforations

by the revolving drums and is passed to a chute or conveyer. This process serves to distribute the moisture evenly and the clay is in a state of preparation which allows convenient manipulation for shaping. The use of this "pill machine," it is claimed, results in a brick which is superior to the ordinary stiff-plastic brick. It is heavier and more solid. R.A.H.

Data. VII. T. W. GARVE. *Clay-Worker*, **97** [5], 260–61 (1932).—The various chemical and physical properties of water are listed and the different kinds of waters are differentiated according to their mineral content, etc. For Part VI see *Ceram. Abs.*, **11** [7], 425 (1932). E.J.V.

Fundamentals and economies in the clay industries. XVI. ELLIS LOVEJOY. *Clay-Worker*, **97** [5], 257–59 (1932).—Some of the many advantages found in using electric current for power are enumerated. Consideration of a Diesel engine is also suggested as a power source. Methods of measuring power requirements are explained. For Part XV see *Ceram. Abs.*, **11** [7] 413 (1932). E.J.V.

Fundamental properties of mortar for durable unit masonry. LEO S. TRAINOR. *Clay-Worker*, **97** [5], 250–53 (1932). E.J.V.

Standard specifications for the brick, stone, and lime industries in Germany and Czechoslovakia. H. HIRSCH. *Tonind.-Ztg.*, **56** [37], 481–86 (1932).—A comparison of different standard specifications of the two countries and some results of tests and testing apparatus are given. W.M.C.

Paving brick for sewers and tunnels. GEORGE SANDENBURG. *Mich. Roads and Airports*, **29** [15], 14–15 (1932).—The advantages of using paving brick in the construction of sewers are pointed out. W.W.M.

A new type of light-weight brick. ANON. *Brit. Clayworker*, **41** [481], 37–38 (1932).—A new German process produces brick consisting of a highly porous core surrounded by a solid casing of clay. Such brick have the appearance of ordinary face brick, but are much lighter in weight. A brief description is given of the machine used for making 2000 of these brick by the stiff-plastic process. R.A.H.

Georgetown high-service reservoir. ANON. *Clay-Worker*, **97** [5], 246–49 (1932).—The Georgetown high-service reservoir, a part of the Washington, D. C., aqueduct, completed in 1861, was a reinforced brick masonry structure. Structural details are given. Illustrated. E.J.V.

Structural clay tile in New York. F. E. EMERY. *Brick Clay Rec.*, **80** [5], 253–54 (1932).—Tile shows a gain in use in New York's skyscrapers, and installations for interior walls and in floors are increasing. Some specific examples are cited. Illustrated. E.J.V.

BOOKS

Report of the Building Research Board, with the Report of the Director of Building Research for the Year 1930. ANON. H. M. Stationery Office. Price 2s 6d net. *Engineering*, **133** [3458], 495–96 (1932).—Some of the important research projects may be grouped under the headings (1) weathering, (2) materials, and (3) strength of materials. A.A.

Rain-Water Penetration through Brick Walls, Its Cause and Prevention. WILHELM THEIN. Chem. Lab. für Tonindustrie und Tonindustrie-Zeitung, Berlin, N. W. 21. *Clay-Worker*, **97** [5], 253 (1932).—The results of an investigation of rain-water penetration through brick walls made in Hamburg, Germany, in 1928 are published. The causes are discussed and methods of correcting these faults are suggested. E.J.V.

PATENTS

Kiln for producing cellular blocks. WARNER HATHAWAY AND KEMPER SLIDELL (American Face Brick Research Corp.). U. S. 1,858,499, May 17, 1932. WARNER HATHAWAY AND E. M. WYATT (American Face Brick Research Corp.). U. S. 1,860,739, May 31, 1932.

Hollow-brick and tile molding machine. LARS FRANDSEN. U. S. 1,858,620, May 17, 1932.

Art of wall construction and building unit therefor. E. D. COVELL (Covell Corp.). U. S. 1,859,236, May 17, 1932.

Method of manufacturing building brick. M. T. STRAIGHT. U. S. 1,859,723, May 24, 1932.

Method and means for closing the ends of the channels of molded hollow channel brick and building block. THOMAS KOIDL. U. S. 1,860,584, May 31, 1932.

Metal lath for brick veneers. FRANK PYRON. U. S. 1,861,359, May 31, 1932.

Brick and building blocks. A. SPRENGER. Brit. 371,905, May 11, 1932.

Manufacture of brick, tile, etc. W. G. MELLS. Brit. 372,112, May 11, 1932. C. MARCHANT. Brit. 372,259, May 11, 1932.

Refractories

Manufacture of first-grade silica brick for the steel industry from crystalline quartzites. I. S. SMELJANSKY AND A. S. FRENKEL. *Trans. Ukrainian Sci. Research Inst. Silicate Ind.*, Sci. Tech. Dept. Supreme Council Nat. Econ. [U.S.S.R.], Vol. XVIII (1931).—The investigated quartzites have the following properties: chemical analysis, SiO_2 97.22, Al_2O_3 0.86, Fe_2O_3 0.78, CaO 0.86, MgO trace, ignition loss 0.28%, specific gravity 2.65, refractoriness Seger cone 34 (1750°C). The experiments have been carried out on laboratory and commercial scale to study the influence of different additions and conditions of manufacture on the rate of inversion of quartz in silica brick. The silica brick obtained were tested in an open-hearth furnace. Conclusions are as follows: (1) The investigated crystalline quartzites are slowly transformed during firing. They are suitable for the manufacture of first-grade silica brick if the batch is well mixed in an edge mill, carefully molded, and fired at Seger cone 16 for 24 hours. (2) Though by a finer granular composition the inversion of quartz is more intensive, the authors recommend the use of a grind of quartzites subjected to a control sieving through a sieve with openings of 5 mm. The contents of grains in size less than 0.5 mm. should be nearly 50%. By the use of such a grind silica brick are obtained having a greater thermal strength and resistance against the action of dust and slag. (3) The introduction into the batch of more than 2% of lime is unnecessary as it lowers the refractoriness of silica brick without increasing the inversion of quartz. (4) Increasing the moisture of the batch improves the quality of the silica brick. The maximum of moisture (by hand molding) should be limited by the ability to retain the regularity of shape of the green brick. (5) The addition of 25% of sand does not lower the quality of the silica brick. (6) The addition of previously fired quartzites in the quantity of 30 to 50% increases, in some measure, the inversion of quartz. For the manufacture of brick not having intricate shapes or of great size, however, such an addition is unreasonable from the economic point of view and only complicates the process of manufacture. (7) The blast-furnace throat dust is a good mineralizer for the inversion of quartz into tridymite. By its introduction into the batch, if the other conditions remain constant, well tridymitized silica brick are obtained. The optimum quantity of this addition is 2%. One advantage of this mineralizer is that being a dust it need not be ground. Its disadvantage is its fluctuating chemical composition depending on the physical state of the materials charged in the blast furnace and of the work of the furnace. (8) Well tridymitized silica brick are obtained with welding slags as mineralizers. The optimum quantity of this addition is 2%. Their advantage is that nearly all the quantity of iron present is in the form of suboxide. The disadvantage is the necessity of fine grinding complicated by their high hardness. (9) The addition of molasses does not influence the inversion of quartz, although its introduction in the quantity of 0.25% is desirable as it considerably decreases the waste of green brick and aids in retaining true corners and edges of the brick. (10) The addition of reducing agents such as coke and charcoal considerably promotes the inversion of quartz into tridymite; especially good results are obtained with charcoal. The introduction of these additions (when ferruginous mineralizers are used) is also necessary to increase the porosity of the silica brick, influencing its thermal strength. The quantity of these additions should be from 1.5 to 2.0%. By increasing their quantity the difficulty of molding increases. S.I.P.

Refractory materials. III. ALEXANDER H. HAYES. *Blast Fur. Steel Plant*, **20** [5], 453–54 (1932).—The manufacturing processes used in the preparation of, and the properties of chromite, dolomite, magnesite, silicon carbide, and zircon refractories are discussed. The effects of reducing, oxidizing, and neutral atmospheres, slags, flue dust, etc., on the properties of the different refractories in service are briefly taken up. For Part II see *Ceram. Abs.*, **11** [6], 370 (1932). E.J.V.

Refractive materials. A. STRIGOTZKII. *Groznenskii Neftyanik*, **1** [4–5], 92–94 (1931).—A fire cement identical in its properties with "Dura-stix" was prepared in the Petroleum Research Institute of Grozneft in Grozny. It contains 72% sand, 12.7% kaolin, 15.3% of a 40°-Bé water-glass solution, and water to give the required consistency. Various tests are described. (*C.A.*)

Refractories and their testing. Evaluation of silica and fire-clay products. ANON.

Abstracted from *Refrac. Bull.*, Nos. 3 and 4 (March and April, 1932); *Chem. Trade Jour.*, **90** [2345], 431–32 (1932).—The primary characteristic of a refractory material is its ability to withstand the action of heat without deforming or softening. This ability varies with different materials, and the degree of resistance to softening shown by each is termed refractoriness. Clays are not simple substances, and when they are heated they do not melt at a definite fixed point but soften over a range of temperature. The Seger cone test is explained and the method of procedure for this test in England is described. A table showing the softening points of Seger cones is given. The refractoriness of a substance is dependent on the chemical composition, or alumina-silica ratio, and the purity of the clay, *i.e.*, absence of fluxes as alkalis and bases. The grain size of the individual particles also affects refractoriness. Normally, the finer the grain is, the quicker the vitrification and softening commence. Refractoriness is considerably decreased under reducing conditions. The chemical composition of a brick is not an infallible guide to its value. Chemical examination shows at once a bad brick, but not necessarily a good one, for good pure material can have inadequate physical properties. The composition of the ideal fire brick is derived from kaolinite, Al_2O_3, $2SiO_2$, $2H_2O$, which gives a fired analysis of alumina 45.9% and silica 54.1%. All fire brick fall short of this, however, since they contain varying proportions of other oxides. Silica is usually present in the largest quantity and it reduces the softening point of a brick. Generally, the higher the silica content, the less refractory it is. Titanium dioxide is not a deleterious constituent although it tends to reduce refractoriness. Iron oxide is present in varying amounts either in the ferrous or ferric state. Ferrous oxide readily forms fusible silicates and is dangerous if the silica content is high. Ferric oxide, at a temperature of 1350° and over, dissociates and becomes an active flux. Lime is a common impurity and is an energetic flux. Magnesia is not a powerful flux and forms much more viscous silicates. Soda and chiefly potash are always present and are active fluxes. The presence of fluxes greatly modifies the toughness, elasticity, strength, and thermal expansion of brick. At high temperatures deformation under load is accelerated, and structural spalling tends to be promoted due to the development of zonal vitrification. Fluxes also greatly intensify corrosion. A table showing the lowest melting of eutectic mixtures of silica and alumina in combination with the principal fluxing oxides is given. Small additions of alumina (up to 5.5%) lower the melting point of silica. Thereafter additions of alumina raise the melting point or with increase of alumina content the refractoriness increases. This is due to the greater amount of crystals of mullite (or corundum) which are formed. The correlation of analyses with the service behavior of fire brick does not always lead to clear-cut conclusions because of the importance of the physical characteristics. See also *Ceram. Abs.*, **11** [7], 418 (1932). M.V.K.

Researches on systems with carbides of high melting point and contributions to the problem of the fusion of carbon. C. Agte and H. Alterthum. *Z. tech. Physik*, **11**, 182–91(1930).—The following carbides were investigated: ZrC, NbC, MoC, Mo_2C, HfC, TaC, WC, and W_2C. The carbides were pressed into the form of rods and sintered in a graphite tube furnace. A hole was inserted in the rods of 0.012 in. diameter and 0.08 in. depth. The rods were held between tungsten clamps and heated in an argon atmosphere. By means of an optical pyrometer, the temperature of the rods was determined, the small hole acting as a black body. The melting took place when the hole became darkened. The melt was investigated by means of a microscope and by X-rays. The melting points of the above carbides are 3805, 3770, 2965, 2960, 4160, 4150, 3140, and 3130°K, respectively. Melting points were also determined for the following binary carbide systems: W_2C–TaC, NbC–W_2C, NbC–TaC, ZrC–TaC, and HfC–TaC. The ternary mixtures of 4TaC·1ZrC with different amounts of NbC resulted in melting points within the range of the components. The formation of new compounds was not observed during the experiments. Mixed crystals, however, were found in almost all systems. The highest melting points hitherto known for solid bodies are the following: 4TaC–1ZrC and 4TaC–1HfC with 4205 and 4215°K, respectively. Carbon was heated in tubes made of TaC. A very heavy evaporation took place at temperatures above 3700°K; the carbide rods showed only a very narrow zone near the surface which may be caused by fusion. The authors believe that a greater amount of fused carbon will only be obtained by heating under pressure. W.M.C.

Researches on the thermal conductivity of refractory materials. Anton Kanz. *Mitt. Forsch.-Inst. Ver. Stahlwerke Akt.-Ges. Dortmund*, **2** [10], 223–34(1932).—A new method for determining the thermal conductivity of refractory materials is described. Because of the smaller size of the sample and its cylindrical form, it was possible to

save much time and to obtain a more uniform heating of the surfaces. Four silica, 2 grog, 2 bauxite, 1 corundum, 2 sillimanite, and 1 chromite brick were investigated. The figures of thermal conductivity of these brick agree well with those obtained by other methods with the exception of those for chromite brick. Silica brick which have already been fired once have a capability of conducting heat which increases with increased temperatures, more under 400° than above it. Thermal treatment influences the formation of tridymite in silica brick. It considerably increases the capability of conducting heat and makes the figure of thermal conductivity dependent on the linear temperature. Irregularities were determined under 300° in alumina blocks, *e.g.*, grog, bauxite, corundum, and sillimanite brick, which are probably influenced by the modification changes occurring in the brick. Well-fired brick did not show these phenomena. In these brick, also, the influence of the dependence of temperature of the figure of thermal conductivity on the firing temperature, in consequence of the formation of crystalline modifications, was determined. The researches showed that the determination of the capability of conducting heat of refractories in the temperature range between 100 and 600° may produce important results because of a greater knowledge of the interior structure of refractories. The great differences in the results obtained by different investigators are due to the inexact methods used. M.V.K.

Researches on the capability of conduction of heat of magnesite blocks. MARTIN BOETTICHER. *Mitt. Forsch.-Inst. Ver. Stahlwerke Akt.-Ges. Dortmund*, **2** [10], 235–48 (1932).—Different magnesite blocks were investigated for their thermal conductivity, characteristics, and structure by X-rays. (1) The specific gravity and the grain size of the block change with a subsequent heating to redness at a temperature which lies considerably above the firing temperature. The length of heating to redness has no effect. (2) The thermal conductivity of magnesite depends directly on the specific gravity and grain size because with their increase produced by subsequent calcining, the thermal conductivity increases. The change of the thermal conductivity is small. (3) No relationships between the thermal conductivity, gas permeability, and porosity were found in the blocks investigated. (4) The lattice perimeter of periclase, contained by magnesite, does not change with a subsequent heating to redness. Its value corresponds to that of pure magnesium oxide within the limits of error. An index of literature on the subject is given. M.V.K.

Testing refractory materials. W. STEGER. Abstracted from *Arch. tech. Messen*, **1** [8], 20–21 (1932); *Feuerfest*, **8** [4], 62 (1932).—S. discusses (1) classification of refractory materials, (2) requirements, (3) different methods of testing, and (4) testing instruments. M.V.K.

Study of the operating requirements for refractory materials in boiler furnaces. PHILIP. *Feuerfest*, **8** [4], 56–59 (1932).—P. discusses investigations made on the behavior of refractories in boiler furnaces in the U. S. M.V.K.

Testing deformation of refractories at high temperatures. V. P. ZEGZHDA. *Ceramics & Glass*, **8** [2], 9–10 (1932); for abstract see *Ceram. Abs.*, **10** [3], 198 (1931). M.V.K.

Permeability of refractory materials. F. DURAU. *Z. tech. Physik*, **13** [5], 228–33 (1932).—The gas impermeability of tubes of different refractory materials was first determined at room temperature. The tubes were then heated to 1200°C and were found to be gas tight at this temperature. Gas was emitted, however, which was not caused by adsorbed gas, but believed to be due to chemically bound gas which was contained within the tubes, mainly near the surface. W.M.C.

Hungarian bauxite. S. DE FINALY. *Giorn. chim. ind. applicata*, **14** [4], 202 (1932).—Hungary has large deposits of the best quality of bauxite which is exported to Germany for the manufacture of aluminum. Bauxite of second quality is used for the manufacture of cement. Researches are being made on the utilization of bauxite containing much silica and iron oxide. Finkey has unsuccessfully tried drying the mineral to reduce transportation costs (see *Ceram. Abs.*, **11** [7], 414 (1932)). Another process by Szarvazy is the electromagnetic treatment of bauxite rich in iron; the bauxite is treated with steam and generator gas at 350 to 600°. The iron oxide is reduced to paramagnetic compounds and separated with an electromagnet. In laboratory tests the mineral was separated into a compound containing 35 to 39% Fe without sulphur and pure bauxite with 75 to 80% Al. M.V.K.

Wear of the lining and changes in working conditions during a converter run. J. POSTINETT. *Stahl Eisen*, **52** [17], 405–409 (1932).—The wear of the converter lining is different at different places of the converter. The heaviest wear is found at the back part. This is caused by passage of air through the converter in a horizontal position, whereas the bulge is protected by the steel melt. A consideration of the changes in

the working conditions leads to the conclusion that the lower part of the converter should be enlarged. W.M.C.

Refractory materials for coke kilns. I. P. P. BUDNIKOFF, G. V. KUKOLEV, AND I. S. SMELJANSKY. *Trans. Ukrainian Research Inst. Bldg. Materials*, No. 21, p. 80 (1931).—The authors discuss (1) conditions of work of refractories in coke kilns, (2) kinds and quality of refractories for them, and (3) behavior of Dinas and half-acid brick used in coke kilns. M.V.K.

Fire brick for lime kilns. ANON. *Brit. Clayworker*, **40** [480], 11 (1932).—Silica brick are much more largely used than formerly, and in many cases are quite satisfactory. Brick and blocks with a high alumina content are good particularly in rotary kilns, but their cost is excessive. Brick containing a large percentage of mullite are ideal. Power-pressed brick are usually more durable than handmade ones provided the pressure is not excessive. R.A.H.

Standardization of refractories in Germany. H. KNUTH. *Feuerfest*, **6** [3], 39–41 (1930).—K. points out the necessity of standard specifications in the refractory industry and the advantages resulting from it for the producer and consumer. Specifications for the size of refractory brick, quality, and testing methods used in Germany are discussed. M.V.K.

BOOKS

Temperature measurements in commercial silicon carbide furnaces. RAYMOND R. RIDGWAY. *Trans. Electrochem. Soc.*, **61** (preprint), 12 pp. (1932).—Three experimental runs on a commercial SiC furnace have been selected to show the limiting temperature in this process. The runs were selected because of specially controlled experimental conditions. Measurements were made with carefully standardized optical pyrometers by trained experimenters. The results are reported in the form of heating curves for various zones in the furnace. An explanation is presented for the shape of these curves as related to what is taking place in the furnace. The earlier published data on this subject are discussed and corrected on the basis of improved temperature measurements. (*C.A.*)

Oxidation rates of silicon carbide and graphite powders. ARCHIBALD H. BALLARD AND RAYMOND R. RIDGWAY. *Trans. Electrochem. Soc.*, **61** (preprint), 12 pp. (1932).—The rates of oxidation of powdered samples of SiC and graphite in O are described. A method was developed for the comparative testing of rates of oxidation of various types of carbide abrasive. This method was then further investigated in the hope of clearing up difficulties repeatedly encountered in the separation of free and total C in chemical analysis. Results given show that the oxidation of a powdered sample of SiC is sufficient to interfere with an exact determination of the amount of free C contained in it. Curves for the oxidation of graphite, under the same control conditions as for the carbide, show that the oxidation of this material in O is not rapid at lower temperatures even when the sample is finely pulverized. Typical rate-of-oxidation curves submitted cover a range of 600 to 1260°. (*C.A.*)

PATENTS

Refractory composition. C. A. LAISE (Callite Products Co., Inc.). U. S. 1,858,244 and 1,858,300, May 17, 1932. (1) A composition of matter comprising tungsten carbide 60 to 85% mixed with a finely divided silicon carbide 2.5 to 15% bonded with molten cobalt 5 to 30%. (2) An alloyed composition of matter comprising tungsten carbide and aluminum oxide in the proportions of 60 to 90% tungsten carbide and 2 to 25% aluminum oxide, bonded with a metal of the iron group.

Treatment of bauxite, clay, and intermediate aluminum-bearing ores. L. G. JENNESS (Intermetal Corp.). U. S. 1,858,272, May 17, 1932. The process of separating aluminum from clay which comprises pulverizing the clay, igniting it at a temperature of 300°C and gradually increasing the ignition temperature to about 900°C, thereby slowly driving off substantially all the water of composition, passing over the clay at a temperature of 400 to 450°C sulphur chlorides and chlorine until substantially all iron and titanium are chlorinated and volatilized, raising the temperature of the ore while the gases are still passing over it to temperatures between 600 and 700°C, thereby reducing, chlorinating, and volatilizing the aluminum oxide content of the clay, and then continuing to heat the clay to between 750 and 850°C, thereby reducing, chlorinating, and volatilizing the aluminum contained in the aluminum silicate in the clay.

Refractory for contact with molten glass. P. G. WILLETTS (Hartford-Empire Co.). U. S. 1,858,317, May 17, 1932. A batch mixture for a ceramic refractory comprising

homogeneous granular grog containing the derivatives of 30% silica and 70% Georgia Klondike kaolin fired to a high temperature and having substantially the same physical and chemical characteristics as the refractory to be produced, and a raw binding material for the grog composed of approximately 30% silica and 70% Georgia Klondike kaolin, both of sufficient fineness to pass a 325-mesh screen.

Furnace construction. R. D. FOLTZ (M. H. Detrick Co.). U. S. 1,858,489, May 17, 1932.

Pulverized fuel furnace. A. E. SMITH AND OSCAR NYGAARD (Bernitz Furnace Appliance Co.). U. S. 1,858,688, May 17, 1932.

Furnace wall. A. E. SMITH AND B. H. SNOW (Bernitz Furnace Appliance Co.). U. S. 1,858,812, May 17, 1932. F. B. BIGELOW (Bigelow-Liptak Corp.). U. S. 1,859,650, May 24, 1932.

Making glass tank blocks, etc. P. G. WILLETTS (Hartford-Empire Co.). U. S. 1,859,227, May 17, 1932. The process of making glass tank blocks which comprises grinding nonplastic kaolin, plastic bond clay, and feldspar to impalpable fineness, mixing a relatively large amount of the nonplastic kaolin with a smaller amount of the plastic bond clay and with a still smaller amount of the feldspar, molding the mixture into blocks by dry-pressing, and firing the blocks so formed to complete vitrification and partial fusion, thereby completely transforming all of the ingredients into crystals and glass.

Method of making refractory. R. P. HEUER (General Refractories Co.). U. S. 1,859,512, May 24, 1932.

Process for the production of silicon carbide and calcium carbide. H. E. WHITE (Swann Research, Inc.). U. S. 1,859,856, May 24, 1932.

Furnace wall structure. F. B. BIGELOW (Bigelow-Liptak Corp.). U. S. 1,861,737, June 7, 1932.

Refractory. G. A. SOPER, JR. U. S. 1,861,759, June 7, 1932. A refractory block comprising a body portion of fire clay having a facing of silicon carbide substantially integral therewith, the facing being of substantial thickness over one face of the block but comparatively thin on the faces adjacent the first-mentioned face.

Making refractory articles. MAX METH (Firth Sterling Steel Co.). U. S. 1,862,191, June 7, 1932. In the method of making refractory articles, the steps comprise mixing zirconium oxide in the presence of hydrochloric acid, shaping the mass, and subjecting it to a sintering temperature.

Fire brick. G. L. TICEHURST. U. S. 1,862,246, June 7, 1932. A substantially elongated rectangular body with teeth-like projections formed on the upper face thereof inwardly from the opposite longitudinal edges of the body.

Saggers for pottery. G. W. NAYLOR, J. F. NAYLOR, W. NAYLOR, AND C. E. NAYLOR. Brit. 340,376, Nov. 18, 1929. Various mechanical details of manufacture are described. (*C.A.*)

Chamotte. FELLNER & ZIEGLER A.-G. Brit. 343,837, Aug. 28, 1929. Chamotte is prepared by firing crushed clay in a rotary furnace at temperatures of 1100 to 1300°. The furnace may have a temperature zone of 800 to 1000° of sufficient length to burn out carbon from bituminous clay or to drive out water before the material reaches the higher temperature zone. (*C.A.*)

Refractory brickwork. P. GIESE. Brit. 371,724, May 4, 1932.

Mold for casting refractory materials. CORHART REFRACTORIES CO. Brit. 372,138, May 11, 1932.

Refractory brick checkerwork for furnace regenerators. W. GILBERTSON & CO., LTD., AND E. THOMAS. Brit. 372,632, May 19, 1932.

Furnace walls. BRITISH THOMSON-HOUSTON CO., LTD. Brit. 373,024, May 25, 1932.

Terra Cotta

Chromium green stains. E. C. HILL. *Jour. Amer. Ceram. Soc.*, **15** [7], 378–81 (1932).

Miscellaneous terra cotta laboratory notes. H. R. GOODRICH. *Jour. Amer. Ceram. Soc.*, **15** [7], 382–85 (1932).

Discoloration of a terra cotta glaze. T. E. NICHOLSON. *Jour. Amer. Ceram. Soc.*, **15** [7], 386–88 (1932).

Influence of variable content of K_2O, CaO, Al_2O_3, SiO_2, and B_2O_3 on the properties

of faience glazes without lead. V. I. ZUBCHANINOV AND S. A. LEVENSHTEIN. *Ceramics & Glass*, **8** [2], 4–7 (1932).—The authors studied seventy-five glazes with a variable content of K_2O, CaO, Al_2O_3, SiO_2, and B_2O_3 oxides. Bodies of different porosity of the feldspar faience type were coated with these glazes and fired at temperatures ranging from 1140 to 1230°. The results obtained served for determining the conditions of glazing, grinding fineness of glazes, and firing. The influence of the separate components on the properties of glazes was as follows: (1) The best results are obtained with bodies having a porosity between 8 and 10%. (2) Too fine grinding of the glaze causes separation into layers which become visible after firing. (3) The firing of glazes should be rapid at first but should slow down toward the end. (4) The amount of SiO_2 (according to the Seger formula) should be between 3.5 to 4.20 mol. The thermal and chemical stability of glazes is increased and the dissolving of colors by the glazes avoided. This amount of SiO_2 must not be increased over 4.20 mol. to avoid the increase of the melting temperature and lowering of the luster of the glaze. (5) The Al_2O_3 content should not be higher than 0.2 to 0.3 mol. to prevent the increase in the melting temperature of the frit and glaze. (6) The K_2O content should be up to 0.6 mol.; it increases the fusibility and permits the increase of the SiO_2 content. (7) K_2O increases the viscosity of the frit, and therefore a part of it can be replaced by Na_2O. (8) The amount of CaO should not be higher than 0.5 to 0.55 mol. because a higher CaO content increases the softening temperature of the glaze and produces a strong opacification of the glaze in the presence of 0.4 B_2O_3. (9) B_2O_3 increases the fusibility of the glaze and improves the luster and transparency. Not less than 0.7 to 1.0 mol. should be used although it dissolves the underglaze colors if the SiO_2 content is low (up to 3 mol.). This defect is avoided by increasing the SiO_2 content. M.V.K.

Glaze of the terra sigillata. BERNHARD NEUMANN. *Sprechsaal*, **65** [14], 253–55; [15], 273–75; [16], 291–93 (1932).—Terra sigillata is a red Roman pottery, with or without relief decoration, prepared from finely washed red-fired clays. It has a very solid, hard, fatty lustrous glaze colored vivid red or red-brown. This pottery reached its highest development in the 1st Century B.C. in Arretium (at present Arezzo) and in Puteoli and Modena. It was famous in antiquity and was exported into Brittany, Spain, Gallia, and Germany where it was later produced. N. discusses the researches of different investigators on the composition of the terra sigillata and its glaze and attempts made to reproduce it, and describes his own investigations. The microscopic testing of the glaze shows that it is not a transparent layer in which definite substances are dissolved or precipitated in crystalline form but that it consists of innumerable yellow-red granules imbedded in a half-vitrified mass or of granules which are surrounded by a more or less melted intermediate layer. The glaze of the terra sigillata is therefore not a proper glaze but a half-vitrified frit which is the reason for the typical heavy or fatty luster. The melting point of the original bodies was shown to be between 1100 and 1150°, and glazes having a softening point much lower that 1100° were used for them. All the alkali silicate glazes produced showed only a brown coloring at the high temperature required. It was also found that all iron colors whose element is an ocher give yellow transparent glazes; those that contain calcined iron oxide as element produce brown to black glazes with a tinge of violet. With frits containing a varied quantity of borax, potash, silica, and brick powder, glazes were obtained similar to those of the real terra sigillata. Such a frit consisted of 1 part by weight of borax, 1.5 potash, 2 silica, and 2 to 4 parts clay. With a firing temperature below 850° the luster can not be obtained, and at a temperature over 950°, the red color changes into brown. Terra sigillata bodies from which the glaze was removed in places were covered with the glaze frits described and the color and luster of these glazes corresponded to those of the original pieces. These researches proved the fact that the old real sigillata glaze can be produced only with the help of boric acid additions, and that the sigillata glaze is an alkali alumina (iron oxide)-borosilicate glass. M.V.K.

Using slag from metallurgy for preparing glazes. S. ALMAZOV-MANEVITCH. *Ceramics & Glass*, **8** [2], 8 (1932).—A. describes researches made to use slags for preparing glazes for ceramic objects. Data on the slag used are given. The slag content amounted to 50% of the weight of the batch which was melted at 1200°. To obtain a vitrified state some saltpeter was added for the oxidation of metal particles present in the slag. The frit obtained varied from light brown to mahogany; it had a sufficient luster and was homogeneous. The glaze obtained was lustrous and had a good adhering power besides being mechanically, chemically, and thermally stable. M.V.K.

Drying terra cotta and faience. FERRUCCIO PELAZZI. *Ind. Silicati*, **10** [4], 12–13 (1932).—The causes of the distortion, deformation, and breaking of terra cotta and faience objects are discussed. M.V.K.

Manufacture of Dutch tile stoves. ANON. *Sprechsaal*, **65** [20], 365–66 (1932).—The chief requirement for a good Dutch tile is a high resistance to the increasing surface temperature and a low thermal conductivity so that the heat accumulated by the tile will not be rapidly given off. Grog is usually used for their manufacture, which is described. The firing is the most important stage in the production; they are fired to about 940° in tunnel kilns, and glazed. For fused Dutch tile limey clays are used. The clays must contain from 20 to 30% calcium carbonate. The working, shaping, firing, and glazing are described. M.V.K.

PATENT

Coating ceramic articles. ALBERT COMES. Ger. 543,269, Aug. 7, 1930. For the production of a terra sigillata coating on ceramic articles, a slip is prepared from a fat ferruginous clay of high swelling capacity and alkaline water, and is allowed to stand, while the liquid is decanted from time to time, until no more sediment is obtained. This may take 4 or 5 weeks. The residual slip is allowed to stand for about 2 weeks more, whereby a gelatinous mass is obtained which is applied to the articles and fired. Gray or black coatings may be obtained by steaming in a known manner. See also *Ceram. Abs.*, **11** [6], 342 (1932). (*C.A.*)

White Wares

Artificial teeth. ALBERT GRANGER. *Céram. verrerie*, **829**, 373–74 (1931).—G. gives a history of the use of artificial teeth. The world's production in 1914 was 121,000,000 which increased to 700,000,000 in 1929. The composition given by Watts is feldspar 81, quartz 14, clay 5. Eisenlohr gives feldspar 73, quartz 24.6, and marble 2.3. The method of manufacture allows the use of materials which have low plasticity. The composition of artificial teeth contains a large amount of feldspar to give vitrification and transparency. In the U. S. a colored enamel is used while in Europe a colored body is employed. The teeth made in the U. S. are more resistant to temperature changes than those made in Europe but the body is more porous. The glossy surface in European practice is obtained by vitrification. Some experimental batches used for coloring teeth are given. T.N.McV.

Artificial teeth. PAUL GRANGER. *Céram. verrerie*, **830**, 435–36 (1931).—A number of batches for coloring teeth are given. If the fused feldspar is too transparent a small percentage of calcium phosphate is added. The teeth are either fired in molds or by molding a stiff paste which contains a small amount of kaolin or an organic binder such as starch. Bronze molds are used which have two or more parts depending upon the shape of the tooth. The enamel is first put in next to the interior side of the mold and the center filled with the body. The molds are closed and fired at 350°C to biscuit the tooth. The teeth are trimmed and fired to temperatures as high as 1400°C. Mention is made of the use of steatite which decreases the shrinkage. The teeth have fastenings of either platinum or nickel. A small closed tube is placed in the tooth during the molding and by means of gold solder the fastenings are welded in these tubes. The teeth are tested for resistance to thermal changes, hardness, and translucency. T.N.McV.

Porcelain manufacture. ANON. Abstracted in *Refrac. Jour.*, **8** [4], 160 (1932); for abstract see *Ceram. Abs.*, **11** [7], 422 (1932). E.P.R.

Testing chemical porcelain ware. D. N. MONASTUIRSKI. *Jour. Applied Chem.* [U.S.S.R.], **4** [5], 671–77 (1932).—M. describes different methods for thermal and chemical tests of porcelain ware used in chemistry. M.V.K.

Some pottery manufacturing faults: their causes and remedies. ANON. *Pottery Gaz.*, **57** [659], 622–26 (1932).—The discussions in connection with nine questions regarding some specific pottery manufacturing faults are presented. E.J.V.

Behavior of dielectrics. BI ELLE. *Ind. Silicati*, **10** [3], 11–14 (1932).—The results of tests on the behavior of dielectrics are given to show how porcelain for electrotechnical use can be perfected in its internal and external structure to make it suitable for every use. M.V.K.

BOOK AND BULLETIN

Soft-Paste Porcelain. A Detailed Study of Porcelain with Indian Materials. SARDAR DOGAR SINGH AND INDU BHUSAN PAUL. Dept. of Industrial Chemistry, Ceramic Section, Benares Hindu University. 21 pp. Printed by Rameshwar Pathak, Tara

Printing Works, Benares, India.—A historical introduction to ceramics, the composition and origin of clays, and the manufacture of ceramic ware are presented. The object of the work is to determine the adaptability of some Indian raw materials in certain ceramic ware, and to determine the properties and characteristics of these raw materials. The locations of the sources of raw materials are given and their physical and chemical properties are tabulated. The materials tested included kaolins, quartz, and feldspar. Binary mixtures of clay and feldspar and clay and quartz were tested and the results tabulated. Five series of porcelain bodies were mixed and tested. Some of them were quite satisfactory. It is concluded that India has satisfactory raw materials for ceramic use but requires technical knowledge and organization to put them to use. W.W.MEYER

Eutectic Glasses as Auxiliary Fluxes in Ceramic Bodies. PAUL F. COLLINS. Ohio State Univ. Eng. Expt. Sta. *Bull.*, No. 68; *Ceram. Ind.*, **18** [5], 294–95 (1932); see also *Ceram. Abs.*, **11** [2], 120 (1932). W.W.M.

PATENT

Compositions for porcelain manufacture. L. NAVIAS (British Thomson-Houston Co., Ltd.). Brit. 346,683, Nov. 13, 1928. The use of ball clay is avoided by adding an aqueous starchy binder such as flour paste, together with a stabilizing agent such as NH_3, NaOH, or KOH to materials such as a mixture of feldspar, flint, Florida kaolin, and china clay, baking, and firing. (*C.A.*)

Equipment and Apparatus

De-airing extrusion machine widens clay industry's possibilities. BONNOT CO. *Brick Clay Rec.*, **80** [5], 248–49 (1932); *Clay-Worker*, **97** [5], 254–56 (1932).—The new de-airing extrusion machine bears some resemblance to the well-known combined pug mill and auger machine, but embodies a number of important changes and additions made necessary by the difficult problem of air evacuation. Tests show that this machine adds greatly to workability and toughness of the clay, has an improved effect on drying and firing of the clays, and results in an improved finished product. Illustrated. E.J.V.

Apparatus for the determination of air in plastic clay bodies. H. SPURRIER. *Ceram. Ind.*, **18** [5], 298–99 (1932).—An apparatus and its method of use for determining the air content of plastic clay bodies are described by S. Some of the advantages of removing gases from pugged clay are given. Illustrated. W.W.M.

Drying ceramic products from the heat technical standpoint. B. HELAN. Abstracted from *Zprávy Československ. keram. společnosti*, **8** [2], 227–28 (1931); *Sprechsaal*, **65** [18], 332 (1932).—During drying of ceramic products under atmospheric pressure and exhausting the air under 100°C, the theoretical heat consumption for the drying installation (expelling 1 kg. water) is given by the heat content of the moist air leaving the drying installation. This heat content is determined from the quantity (in kilograms) of escaping air required for exhausting 1 kg. of water at a given degree of saturation and given temperature and through the heat content of 1 kg. moist air. The heat consumption is small when the temperature and moisture content of the escaping air is high. Data on different types of drying installations used in the brick industry are given and the course of the humidity and temperature of the moist air in different drying installations during the drying time is represented in diagrams. M.V.K.

Determining the quantity of water absorbed by air during drying. ANON. *Rev. mat. constr. trav. pub.*, No. 271, pp. 64–67*B* (1932).—Tables and diagrams show how many grams of water vapor can be absorbed by 1 kg. of air at a definite temperature and definite degree of saturation, and the amount of heat necessary for obtaining this result is given. Illustrated. M.V.K.

New drying plant for brick. H. MAGER. *Tonind-Ztg.*, **56** [35], 459–61 (1932).—This drying plant is built in a similar way to a drying plant for china, etc. The brick are moved through low canals heated from a tunnel kiln. The costs of building and operating the plant are given. W.M.C.

Drying brick. FRANCESCO MORANDI. *Corriere Ceram.*, **13** [3], 89–95 (1932).—M. discusses the causes of the cracking of brick during drying. M.V.K.

Science and practice of drying. XIV. ANON. *Brit. Clayworker*, **41** [481], 34–35 (1932).—The Boss drier is described. The economies of the Standard drier heated by batteries of small diameter steam piping beneath the car tracks and of the Moller and

Pfeifer tunnel drier which uses the principle of direct ventilation are given. For Part XIII see *Ceram. Abs.*, **11** [7], 424 (1932). R.A.H.

New hardness testers. A. C. B. *Instrument World*, **4**, 195 (1932).—Two new testers introduced into the U. S. are (1) the Rockwell direct-reading tester which avoids depth readings under varying loads, and (2) the Duroskop which depends on the dynamic principle of a falling pendulum. H.H.S.

Tungsten-molybdenum thermocouple. ANON. *Instrument World*, **4**, 186 (1932).—The W-Mo couple is useful from 1200°C upward. In oxidizing atmospheres it requires a protecting sheath. With the development of refractories impervious to gases at high temperatures, the range of the couple will accordingly increase. H.H.S.

An instrument for the photometering of the new X-ray lines. WILLIAM DUANE. *Proc. Nat. Acad. Sci.*, **18** [4], 322–28 (1932).—A photometer for drawing curves of X-ray spectra is described. It was constructed to examine in detail the X-ray K series spectrum in which the author has found a number of new lines. Illustrated. See also *Ceram. Abs.*, **11** [4], 269 (1932). J.L.G.

Improved comparison source for measuring furnace temperatures. E. M. WATSON AND W. P. ZABEL. *Gen. Elec. Rev.*, **34**, 120–21(1932).—A small pyrometer lamp has been devised that differs from an optical pyrometer in that the objective lens and the telescope are not used. The optical system for the pyrometer lamp and the optical pyrometer are charted for comparison. The operation of the lamp is briefly outlined. (*C.A.*)

Grinding plant research. IV. Tests of coal grinding mills. WILLIAM GILBERT. *Rock Prod.*, **35** [8], 40–43 (1932).—G. describes various coal grinding tests, giving results illustrated with tables, graphs, and sketches. For Parts II and III see *Ceram. Abs.*, **11** [6], 377 (1932). W.W.M.

Electric traction with batteries. ANON. *Rev. mat. constr. trav. pub.*, No. 271, pp. 68–72*B* (1932).—Electric conveyers, sliding carriages, and carts used in plants are described. M.V.K.

Laboratory electric furnace for high temperatures. W. WEYL AND M. BICHOWSKY. *Chem. Fabr.*, No. 49, p. 469 (1931).—A new electric furnace developed by the Kaiser-Wilhelm Institut für Silikatforschung is described. In this furnace a temperature of 1550° can be obtained and kept constant for several hours; for a short time, temperatures up to 1600° can be reached. The furnace may be used for drawing up heating and cooling curves, for investigating silicate equilibrium according to the static method, for measuring the properties of different materials at high temperatures, and for analytical purposes. M.V.K.

Two-inch power plant. WESTON ELECTRICAL INSTRUMENT CORP. *Maintenance Eng.*, **90** [4], 163–65 (1932).—The Weston "photronic cell" is a light-sensitive control device capable of producing enough current to operate controls. Illustrated with charts and photos. J.L.G.

Gas engine drive for brickworks. ANON. *Brit. Clayworker*, **41** [481], 36–37 (1932).—The advantages of the gas engine in comparison with the electric motor and oil engine for motive power in brickworks are described. R.A.H.

Dew-point recorder for flue gases. ANON. *Engineering*, **133** [3458], 480–81 (1932).—The instrument designed and constructed by the Cambridge Instrument Co., Ltd., for the purpose of recording the actual temperature at which moisture will be deposited from the flue gas, regardless of the chemical composition of the flue gas, is described and illustrated. A.A.

CIRCULAR

Method and cost of quarrying, crushing, and grinding limestone at the Security Quarry of the North American Cement Corp., Security, Md. A. W. COX. Bur. Mines *Information Circ.*, No. 6554. 14 pp. Free. R.A.H.

PATENTS

Clayworking machine. H. H. MONTAGUE. U. S. 1,859,675, May 24, 1932.

Method of molding hollow clay bodies. MAXWELL GERSON DUMAS. U. S. 1,859,768, May 24, 1932.

Method of making screen plates. W. E. MCMURRAY (Clearfield Machine Co.). U. S. 1,859,784, May 24, 1932.

Hacking machine. C. E. FULLER AND W. W. WALLACE (New York Brick Handling Corp.). U. S. 1,860,143, May 24, 1932.

Fritting furnace. J. F. RYAN AND CHARLES STEGMAYER (Mutton Hollow Fire Brick Co.). U. S. 1,861,138, May 31, 1932.

Process of drying china clay. W. BOULTON, LTD., AND T. H. GASKELL. Brit. 371,346, May 4, 1932.

Method and apparatus for making molten masses and slags become highly porous as they solidify. C. H. SCHOL. Brit. 372,197, May 11, 1932.

Drying apparatus for ceramics, etc. H. HAAS. Brit. 372,700, May 19, 1932.

Device for drying ceramic ware in a moist warm air current. JOSEF DENGLER. Ger. 541,558, Jan. 24, 1929. (*C.A.*)

Kilns, Furnaces, Fuels, and Combustion

Increasing kiln output. ANON. *Brit. Clayworker*, **40** [480], 10 (1932).—Short continuous kilns are unprofitable. It has been shown repeatedly that the minimum effective length of a continuous kiln should be 240 ft. This applies only to kilns which are supplied with perfectly dry brick. If damp brick are supplied the length of the kiln must be increased according to the number of days required to dry them in the kiln. The only means of correcting a short kiln is to increase the length by building an addition. Some continuous kilns have a suitable effective length but a low output which is often due to defective draft. This is not caused by an unsuitable chimney, but is due to the baffling action of the steam from the recently set brick and those just below red heat. A low output is sometimes due to excessive caution on the part of the firemen, who take too long in the preheating, full-fire, annealing, or cooling periods or in any one of them. A low output may also be due to the kiln not being supplied regularly with brick. R.A.H.

Tunnel kilns in the ceramic industry. N. N. NORKIN. *Ceramics & Glass*, **8** [2], 30–33 (1932).—The history of the development of tunnel kilns and their work in the U.S.S.R. is treated. Data characterizing the advantages of tunnel kilns with respect to fuel consumption, shortening of firing time, and improved quality of fired ware are given with two diagrams of thermal balances. M.V.K.

A mechanized kiln for drying and firing brick. ANON. *Brit. Clayworker*, **41** [481], 39–40 (1932).—The apparatus described, including in its scope a means for drying plastic ware, is such that from the time the clay is fed to the preparing machinery until the moment when the brick are cooled after firing, there is no labor of any kind expended on handling them. The general principle of its action is similar to that of the tunnel kiln, but in the mechanized kiln there is the difference that the ware is placed directly on metal trays which are able to withstand the temperature of 1150°C for long periods of use. A detailed description is given of the apparatus and firing operations. R.A.H.

Systems of installations with recuperators for brick kilns. ADOLFO CARENA. *Ind. Silicati*, **10** [2], 13–16 (1932).—A description is given of a simplified system of installations with a multiple recuperator, with a multiple recuperator functioning by induction, and with a multiple recuperator with air. See also *Ceram. Abs.*, **11** [4], 259 (1932). M.V.K.

Brick firing with crude oil. H. KREMSKI. *Tonind.-Ztg.*, **56** [38], 495–96 (1932).—A brick plant near Bagdad, Mesopotamia, which contains a Hoffman ring kiln fired with crude oil is described. W.M.C.

Economic firing of brick. GIOVANNI RORER. *Corriere Ceram.*, **13** [3], 95–97 (1932).—The danger of increasing the amount of waste when attempting to economize on fuel consumption in firing brick is discussed. M.V.K.

Heating with fuel oil in ceramics. A. LEDUC. *Corriere Ceram.*, **13** [4], 139–56 (1932); for abstract see *Ceram. Abs.*, **11** [2], 127 (1932). M.V.K.

Removal of dust from power station flue gases. ANON. *Engineering*, **133** [3459], 532 (1932).—The dust in the gases discharged from power-station chimneys is composed partly of noncombustible mineral matter and partly of coal and coke the combustion of which has not been completed. The size of the dust varies considerably with stoker firing and with pulverized fuel firing. The concentration of dust particles does not usually exceed one grain per cu. ft. with stoker firing, but with pulverized fuel concentrations of 4 grains per cu. ft. are common. Methods of removal are discussed. The paper "Review of the methods of dust removal from power station flue gases," by J. Mayer, read before the North-Western Section of the Institute of Fuel in Manchester, April 22, is also discussed. A.A.

Errors to avoid when firing with natural gas. H. C. KENYON. *Brick Clay Rec.*, **80** [5], 251–52 (1932).—An explosive natural gas requires careful handling. If burned

at high pressure it is liable to blow out. Method of control in kiln firing is given. Illustrated. E.J.V.

Firing of stoneware pipe in the ring kiln. ANON. *Tonind.-Ztg.*, **56** [38], 498–99 (1932). W.M.C.

Complete gasification and gas generators. L. LITINSKY. *Feuerfest*, **8** [4], 49–56 (1932).—L. discusses the processes of gasification, heat-technical efficiency, heat value, and the question of coke. M.V.K.

Heat balances for kilns. G. NEUMANN. *Arch. Eisenhüttenwesen*, **5** [9], 471–75 (1932).—This paper gives a review of the items to be considered for the compiling of heat balances for kilns. The different heat losses are discussed. Diagrams for the heat consumption are given. W.M.C.

BOOKS AND BULLETIN

Laboratory Manual of Gas, Oil, and Fuel Analysis. C. J. ENGELDER. x + 236 pp. Chapman and Hall, Ltd., London, and J. Wiley and Sons, New York, 1931. Reviewed in *Chem. & Ind.*, **51** [19], 406 (1932); for abstract see *Ceram. Abs.*, **11** [2], 130 (1932). G.R.S.

Analysis of Fuel, Gas, Water, and Lubricants. S. W. PARR. 4th ed. McGraw-Hill Book Co., New York. 371 pp. Price $3.00. *Mining & Met.*, **13** [305], 255 (1932). E.J.V.

Washability Tests of Illinois Coals. A. C. CALLEN AND D. R. MITCHELL. Price 60¢. Univ. of Ill. Eng. Expt. Sta. *Bull.*, No. 217, 114 pp. (1930); *Power Plant Eng.*, **35** [5], 338 (1931).—Selecting a few typical mines, the following studies were made: (1) occurrence of the visible impurities in the coal and the nature of the roof and floor; (2) methods of mining and the determination of their effect on the impurities in the mined coal; (3) consideration of the possibilities of hand picking the coals; (4) detailed investigation of washability of adequate samples of the mined coal; (5) determination of the amount and distribution of ash and the different forms of sulphur; (6) determination of the yields of washed coal and the limits of the reduction of ash and sulphur percentages; and (7) observation of the variation in the fusion point of the ash of raw coal and washed coal. Preparation of coal is defined as the removal from coal of part of its separable impurities and the sizing of the coal, both in response to the demands of the market. Under the preparation of coal, general features, impurities in coal and their effects, factors affecting washability, and coal washing processes are discussed. Under washability tests are given mine examinations, tipple samples, chemical analyses, float-and-sink tests, and development and interpretation of washability curves. A general summary of the washability of the coal is made by comparing the yield and analyses of the separation products made at selected specific gravities. This comparison is given in Table 44. The names assigned to the three separation products, clean coal, middlings, and refuse, are expressive of the character of these products. For comparison the results are given on a moisture-free basis, so the percentages of ash and sulphur are somewhat higher numerically than if they were given on as-mined or as-received basis. The investigation brings out clearly the fact that, excluding Mine F, none of the coal from the mines that were sampled can be made to yield a low sulphur coal by any preparation or washing process. A study of the float-and-sink summary tables shows that even with coal as fine as 20-mesh the sulphur in the 1.30 float product is almost always greater than 2.25% and in only one or two cases is less than 2.00%. The average organic sulphur in the channel samples ranged from about 1.2 to 1.8%. Since organic sulphur is not removable by any known process, it is indicated that the lowest sulphur percentage that can be obtained by any washing process is the percentage of organic sulphur that is in the coal. If all the pyrite were in lump form and could be freed by crushing through, a clean coal with approximately the limiting percentage of sulphur (the per cent of organic sulphur) could be produced. It is well known, however, that some of the pyrite is present in microscopic particles averaging about $^1/_{500}$ inch and less in diameter. Crushing even to 200-mesh would not free all of this material and the finest float coal will show pyrite sulphur. On 10- x 20-mesh, 1.30 specific gravity float coal from Mines B, C, and E, the percentages of the pyrite sulphur were 0.61, 0.38, and 0.86, respectively, with higher percentages in the float coal from the heavier gravity solutions. In all coals but those of Mine F, a large amount of sulphur remains after preparation and washing, due to high organic sulphur and inseparable pyrite. A.A.

PATENTS

Twin tunnel kiln. W. L. HANLEY, JR. U. S. 1,859,507, May 24, 1932.

Tunnel kiln. E. B. FORSE AND C. F. GEIGER (Carborundum Co.). U. S. 1,861,266, May 31, 1932.

Firing ceramic materials. J. E. POLLAK (Porzellanfabrik Kahla). Brit. 371,440, May 4, 1932.

Brick. FRANCO BANDINI. Fr. 717,853, May 28, 1931. Brick are dried and fired at the same time by placing them in an open box of refractory material and in a mass of sand and powdered or liquid fuel, the boxes being introduced one after another into a long tunnel furnace where drying and firing are effected by the fuel in the mass of sand. (*C.A.*)

Apparatus for estimating the heating value of solid and liquid fuels by measuring the oxygen required for combustion. ALEXEJ LOMSCHAKOFF. Ger. 544,136, May 9, 1926. (*C.A.*)

Circular, multichamber oven for firing Dinas and other refractories. V. E. GROUM-GRJIMAILO. Russ. 4332; granted Sept. 15, 1924; published July 31, 1928. (*C.A.*)

Geology

Clarion clay of Vinton County, Ohio. WILBER STOUT. *Jour. Amer. Ceram. Soc.*, **15** [7], 397–406 (1932).

Progress report on the study of southern Illinois silica as a pottery material. C. W. PARMELEE. Ill. State Geol. Surv. *Rept. of Invest.*, No. 24, 3–7(1932). (*C.A.*)

Crystal structures of some natural and synthetic apatite-like substances. S. B. HENDRICKS, M. E. JEFFERSON, AND V. M. MOSLEY. *Z. Krist.*, **81** [5–6], 352–69 (1932).—A study was made of the crystal structures of the compounds forming the "apatite group." Structural reasons were deduced accounting for the apparent isomorphous replacement of fluorine ions by carbonate, hydroxyl, sulphate, and silicate groups and by oxygen, chlorine, bromine, or iodine ions. A rational explanation is thus possible for the occurrence of the various poorly defined mineral components of phosphate rock. The probable existence of a compound $Ca_{10}ClF(PO_4)_6$ is pointed out. A structural reason is given for the limited replacement of fluorine by chlorine in natural fluorapatite. The X-ray powder diffraction photographs of oxyapatite, $Ca_{10}O(PO_4)_6$, a hydrate of tricalcium phosphate, $Ca_9(H_2O)_2(PO_4)_6$, and a phosphate compound of bone, $Ca_{10}(CO_3)(H_2O)(PO_4)_6$, differ but slightly from those of hydroxy- and fluorapatite. G.R.S.

Ptilolite from Utah. W. T. SCHALLER. *Amer. Mineralogist*, **17** [4], 125–27 (1932).—A description is given of the crystals. Their optical properties and chemical composition are shown in tables. The formula of the mineral is $(Ca, K_2, Na_2)O{\cdot}Al_2O_3{\cdot}10SiO_2{\cdot}7H_2O$. It fuses quietly and fairly readily to an opaque white enamel. G.R.S.

Mordenite-ptilolite group; clinoptilolite, a new species. W. T. SCHALLER. *Amer. Mineralogist*, **17** [4], 128–34 (1932).—By correlating the data as to composition, crystallography, and optical properties, supplemented by new determinations, S. shows that three distinct species are represented by these high-silica, acid-insoluble, zeolite-resembling minerals. Mordenite is represented by the formula, $(Ca, K_2, Na_2)O{\cdot}Al_2O_3{\cdot}9SiO_2{\cdot}6H_2O$. Clinoptilolite is a dimorphous form of ptilolite. G.R.S.

Montmorillonite or smectite as constituents of fuller's earth and bentonite. P. F. KERR. *Amer. Mineralogist*, **17** [5], 192–98 (1932). G.R.S.

Clays and clay products industry in Western Canada. G. M. HUTT. *Pre-Cambrian*, **5** [2], 18–23 (1932). G.R.S.

Zircon. VICTOR CHARRIN. *Rev. mat. constr. trav. pub.*, No. 271, pp. 61–62*B* (1932).—C. details the occurrence and variety of zircon minerals. The African and Madagascar deposits of zircon and their mining are described. M.V.K.

Kaolin in Hungary. S. DE FINALY. *Giorn. chim. ind. applicata*, **14** [4], 202 (1932).—Tests made by Gyorke on the kaolin of the Sarospatak region showed that this mineral can be converted into 98% pure kaolin by washing. The same treatment is applicable to earths rich in Zettlitz kaolin. Gyorke also studied a mineral containing 73.5% siliceous anhydride, 64.5% of which can be dissolved by heating 3 hr. with a 10% solution of caustic soda. The alkaline silicate can be used in the production of glass or in the building of roads. M.V.K.

Basaltic glass. R. E. FULLER. *Amer. Mineralogist*, **17** [3], 104–107 (1932).—Evidence of aqueous chilling of a number of basaltic flows is given, and the alterations of the glass are described. G.R.S.

Fluorine and its industrial use. CHARRIN. *Ind. chimique*, **18** [215], 889 (1931); for abstract see *Ceram. Abs.*, **10** [12], 859 (1931). M.V.K.

BOOKS

A Manual of Determinative Mineralogy with Tables for the Determination of Minerals by Means of (1) Their Physical Characters; (2) Blowpipe and Chemical Properties; (3) Optical Properties. J. VOLNEY LEWIS. 4th ed., revised by A. C. Hawkins. ix + 230 pp. John Wiley and Sons, Inc., New York, 1931. Price $3.00. Reviewed in *Amer. Mineralogist*, **17** [3], 123 (1932). G.R.S.

Microscopic Characters of Artificial Inorganic Solid Substances or Artificial Minerals. A. N. WINCHELL. With a chapter on the Universal Stage by R. C. Emmons. 2d ed. xvii + 403 pp. Reviewed in *Chem. & Ind.*, **51** [19], 397–98 (1932); for abstract see *Ceram. Abs.*, **11** [5], 323 (1932). G.R.S.

The Minerals of Connecticut. JOHN FRANK SCHAIRER. Conn. State Geol. and Natural History Surv. *Bull.*, No. 51., vii + 121 pp.; reviewed in *Amer. Mineralogist*, **17** [5], 200 (1932). G.R.S.

Engineering Geology. H. RIES AND T. L. WATSON. 4th ed. John Wiley and Sons, Inc., New York, Chapman and Hall, Ltd., London. Price 25s net. Reviewed in *Engineering*, **133** [3459], 510 (1932); see also *Ceram. Abs.*, **10** [9], 660 (1931). A.A.

The Figure of the Earth. NATIONAL RESEARCH COUNCIL. vi + 286 pp. National Academy of Sciences, Washington, 1931. Reviewed in *Geographical Jour.*, **79**, 239–40 (1932).—This is Vol. 2 of a series on the physics of the earth. H.H.S.

Feldspars and Their Practical Determination. (Die Feldspate und ihre praktische Bestimmung.) KARL CHUDOBA. Erwin Nägele, Stuttgart, 1932. 46 illustrations. 6.00 Rm. Reviewed in *Sprechsaal*, **65** [20], 380–81 (1932).—C. gives extensive literature on feldspars and discusses the different methods of determination used. Separate chapters of the book treat the chemical composition of feldspar, its morphological characteristics, and the determination of alkali-feldspar and plagioclase by means of the microscope. M.V.K.

Chemistry and Physics

Occurrence and properties of crystalline alumina in silicate melts. HELEN BLAIR BARLETT. *Jour. Amer. Ceram. Soc.*, **15** [7], 361–64 (1932).

Emmons double-variation apparatus for crystal determination. R. C. EMMONS. *Instrument World*, **4**, 187 (1932).—E.'s method depends on the variation of refractive index with the wave-length of the light used and with temperature. A series of immersion liquids for which the dispersions have been determined is presupposed. H.H.S.

Significance of "block structure" in crystals. M. J. BUERGER. *Amer. Mineralogist*, **17** [5], 177–91 (1932).—An apparent subdivision into block-like subunits in almost parallel orientation is very common in crystals. It is shown that actually the subunits are not separate blocks or grains, but are continuous with each other by way of the parent crystal nucleus forming a rudely spherically-symmetrical, tree-like structure. The term lineages is introduced to cover such crystal subdivisions. The origin of lineages is ascribed to structural distortions which are surmised to arise either from the Zwicky surface cracks in crystals or from improperly distributed solid solution impurities. G.R.S.

Radiation from crystals and from the grain limits of oxides. F. SKAUPY AND H. HOPPE. *Z. tech. Physik*, **13** [5], 226–28 (1932).—The influence of the size of grains was investigated as a function of the wave-length. The radiation of nonmetallic substances generally originates at the limits of the grains, especially with white oxides. W.M.C.

Total radiation from several oxides. GERHARD LIEBMANN. *Z. Physik*, **71** [7–8], 416–21 (1931).—The total radiation of oxides was measured as a function of temperature, composition, and grain size. The wattmetric method was used for the determination of the radiation. By this method the electrical energy taken up by the oxide is decreased by that lost by convection which is the energy given up as radiation. The energy was also measured with thermopiles which are calibrated from the radiation from a black body. The oxides studied included the Nernst mass, which is a mixture of 85% ZrO_2 and 15% yttrium oxide, Al_2O_3 in grains 1 to 2μ and 2 to 4μ, MgO, ThO_2, and CeO_2. The radiation in per cent based on the radiation from a black body is

plotted as a function of the temperature. CeO_2 approaches that of a black body most nearly; at 1600° it is 90%. The Nernst mass gives a radiation of 80% at 2200°C.
L.T.B.

Total radiation of some oxides and oxide mixtures. KURT HILD. *Mitt. Kaiser-Wilhelm Inst. Eisenforsch. Düsseldorf*, **14** [5], 59–70 (1932).—H. describes researches on (1) the total radiation of the pure oxides, Al_2O_3, MgO, CaO, SiO_2, Cr_2O_3, Fe_2O_3, and ZnO; (2) influence of the grain size and nature of the radiators; (3) total radiation of oxide mixtures, CaO-MgO, Al_2O_3-MgO, Al_2O_3-Cr_2O_3, and Al_2O_3-ZnO; (4) formation of the spinel Al_2ZnO_4 through reaction in solid state. It is concluded that a survey of different phenomena can be obtained from the measurements of radiation of oxide mixtures. According to the influence of oxide in mixtures, both groups of the white and colored oxides can be separated. The white oxides are those of light metals, the colored, those of heavy metals. The main difference between them is that in a mixture of white oxides the radiation is not influenced, or only slightly, by each oxide, while the radiation of a mixture of colored and white oxides does not result from the radiation capacity of the components corresponding to their composition. This seems to be true whether they are simple oxides or compositions of oxides. The radiation of white oxides is considerably influenced through an addition of a colored oxide. Zinc oxide in its mixture with aluminum oxide acts as a coloring oxide (the kind of reciprocal action is not known yet), in which case a definite addition has the greatest effect. On the other hand, it behaves as a white oxide in the spinel, Al_2ZnO_4. The high emission of refractory materials has not been well explained. The radiation of their chief constituents, *i.e.*, alumina and silicon dioxide, does not grow over 0.56 or 0.42 up to 1350°. That of the mixtures is not higher. In mixtures with iron oxide (1 to 3%), a considerable increase in radiation was determined. This undesirable admixture therefore causes a high radiation of the refractory material and consequently a much better balance of heat in the kiln. Measurements of the dependence of the total radiation on the grain size showed that a comparison of radiation of different materials is possible only when the grain size is equal or when the dependence of radiation on the grain size is known. This is also true for refractories. The variation in results is partly due to the influence of the grain size. The stronger the refractories are vitrified, the higher their radiation is expected to be. The influence of the state of the structure on radiation is given by the roughness of the surface, although the capability of absorption of the refractory has a certain effect in that, with a higher absorption, the amount of radiation in a hollow space must be higher due to unevennesses.
M.V.K.

Sorption phenomena in soils and in silica gels. ELIZABETH D. DE PARAVINCI. *Soil Sci.*, **33** [3], 163–81 (1932).—A study was made of conductivity and p_H measurements on aqueous suspensions of soils and silica gels, correlating the results with those obtained for samples which were subjected to an initial heat treatment. Addition of neutral chloride solutions increases the acidity of soil and gel suspensions but effects a simultaneous decrease in conductivity. This shows sorption of ions in great excess to those taking part in base exchange. Different cations were shown to displace hydrogen preferentially, but experiments on a "hydrogen" soil and on silica hydrogel show equivalent sorption of the cations Na, K, Mg, and Ca. For five typical soils, an optimum temperature between the limits 110 to 150°C, was found to give maximum values for the acidity and conductivity of resulting suspensions and also for subsequent sorption of cations. For silica hydrogels the effects appear to be completely reversible.
G.R.S.

Laws of soil colloidal behavior. VIII. Forms and functions of water. SANTE MATTSON. *Soil Sci.*, **33** [4], 301–23 (1932).—The combined or constitutional water represents the internal water of the material in combination with the individual molecules in the form of hydrous oxides of silicon, aluminum, iron, and their combinations. The molecularly attracted water is represented by the hygroscopic moisture. This water is held by powerful forces which are manifest by the heat of wetting and by a contraction of volume. This water exists in a thin film which apparently does not exceed 4 or 5$\mu\mu$ in thickness, corresponding to the range of molecular attraction. The quantity of water thus absorbed by the soil is a function of the surface and is independent of the nature and quantity of exchangeable cations. Soil colloids imbibe greatly varying quantities of water depending upon (1) their composition or more directly upon their exchange capacity, (2) the nature of the exchangeable cations, (3) the charge of the particles, (4) the position of their isoelectric point if amphoteric, (5) their ultimate p_H, *i.e.*, the strength of their acid group, and (6) the concentration of free electrolytes and the valence of the ions, both according to the Donnan equilibrium. This imbibition is obviously a function of an ionic condition of the colloid. It is an osmotic imbibition

Fluorine and its industrial use. CHARRIN. *Ind. chimique*, **18** [215], 889 (1931); for abstract see *Ceram. Abs.*, **10** [12], 859 (1931). M.V.K.

BOOKS

A Manual of Determinative Mineralogy with Tables for the Determination of Minerals by Means of (1) Their Physical Characters; (2) Blowpipe and Chemical Properties; (3) Optical Properties. J. VOLNEY LEWIS. 4th ed., revised by A. C. Hawkins. ix + 230 pp. John Wiley and Sons, Inc., New York, 1931. Price $3.00. Reviewed in *Amer. Mineralogist*, **17** [3], 123 (1932). G.R.S.

Microscopic Characters of Artificial Inorganic Solid Substances or Artificial Minerals. A. N. WINCHELL. With a chapter on the Universal Stage by R. C. Emmons. 2d ed. xvii + 403 pp. Reviewed in *Chem. & Ind.*, **51** [19], 397–98 (1932); for abstract see *Ceram. Abs.*, **11** [5], 323 (1932). G.R.S.

The Minerals of Connecticut. JOHN FRANK SCHAIRER. Conn. State Geol. and Natural History Surv. *Bull.*, No. 51., vii + 121 pp.; reviewed in *Amer. Mineralogist*, **17** [5], 200 (1932). G.R.S.

Engineering Geology. H. RIES AND T. L. WATSON. 4th ed. John Wiley and Sons, Inc., New York, Chapman and Hall, Ltd., London. Price 25s net. Reviewed in *Engineering*, **133** [3459], 510 (1932); see also *Ceram. Abs.*, **10** [9], 660 (1931). A.A.

The Figure of the Earth. NATIONAL RESEARCH COUNCIL. vi + 286 pp. National Academy of Sciences, Washington, 1931. Reviewed in *Geographical Jour.*, **79**, 239–40 (1932).—This is Vol. 2 of a series on the physics of the earth. H.H.S.

Feldspars and Their Practical Determination. (Die Feldspate und ihre praktische Bestimmung.) KARL CHUDOBA. Erwin Nägele, Stuttgart, 1932. 46 illustrations. 6.00 Rm. Reviewed in *Sprechsaal*, **65** [20], 380–81 (1932).—C. gives extensive literature on feldspars and discusses the different methods of determination used. Separate chapters of the book treat the chemical composition of feldspar, its morphological characteristics, and the determination of alkali-feldspar and plagioclase by means of the microscope. M.V.K.

Chemistry and Physics

Occurrence and properties of crystalline alumina in silicate melts. HELEN BLAIR BARLETT. *Jour. Amer. Ceram. Soc.*, **15** [7], 361–64 (1932).

Emmons double-variation apparatus for crystal determination. R. C. EMMONS. *Instrument World*, **4**, 187 (1932).—E.'s method depends on the variation of refractive index with the wave-length of the light used and with temperature. A series of immersion liquids for which the dispersions have been determined is presupposed. H.H.S.

Significance of "block structure" in crystals. M. J. BUERGER. *Amer. Mineralogist*, **17** [5], 177–91 (1932).—An apparent subdivision into block-like subunits in almost parallel orientation is very common in crystals. It is shown that actually the subunits are not separate blocks or grains, but are continuous with each other by way of the parent crystal nucleus forming a rudely spherically-symmetrical, tree-like structure. The term lineages is introduced to cover such crystal subdivisions. The origin of lineages is ascribed to structural distortions which are surmised to arise either from the Zwicky surface cracks in crystals or from improperly distributed solid solution impurities. G.R.S.

Radiation from crystals and from the grain limits of oxides. F. SKAUPY AND H. HOPPE. *Z. tech. Physik*, **13** [5], 226–28 (1932).—The influence of the size of grains was investigated as a function of the wave-length. The radiation of nonmetallic substances generally originates at the limits of the grains, especially with white oxides. W.M.C.

Total radiation from several oxides. GERHARD LIEBMANN. *Z. Physik*, **71** [7–8], 416–21 (1931).—The total radiation of oxides was measured as a function of temperature, composition, and grain size. The wattmetric method was used for the determination of the radiation. By this method the electrical energy taken up by the oxide is decreased by that lost by convection which is the energy given up as radiation. The energy was also measured with thermopiles which are calibrated from the radiation from a black body. The oxides studied included the Nernst mass, which is a mixture of 85% ZrO_2 and 15% yttrium oxide, Al_2O_3 in grains 1 to 2μ and 2 to 4μ, MgO, ThO_2, and CeO_2. The radiation in per cent based on the radiation from a black body is

plotted as a function of the temperature. CeO_2 approaches that of a black body most nearly; at 1600° it is 90%. The Nernst mass gives a radiation of 80% at 2200°C.
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brought about by the dissociation of diffusible ions by the colloidal particle. This forms the colloidal micella consisting of the particle, the ion atmosphere, and the osmotically imbibed water. For Part VII see *Ceram. Abs.*, **11** [4], 280 (1932). G.R.S.

Factors affecting the amount of electrodialyzable ions liberated from some soils. A. LÖDDESÖL. *Soil Sci.*, **33** [3], 187–211 (1932).—The conditions investigated were differences in (1) the concentration of the soil suspension, (2) the distance between the electrodes, (3) voltage, and (4) membranes. The results are given in connection with the description of the various experiments. Determinations of the total amounts of exchangeable cations in the investigated soils by extraction with ammonium acetate were also made. The results were compared with the results from the electrodialysis experiments and an attempt was made to distinguish between the total quantities of cations liberated from the soils and the amounts of exchangeable cations. G.R.S.

Investigations concerning separation of similarly charged ions from soils by electrodialysis. A. LÖDDESÖL. *Soil Sci.*, **33** [5], 375–94 (1932).—It was found that Fe, Al, and Mg under certain conditions migrated to the anode, presumably in the form of complexes consisting of hydroxides which had absorbed acid ions. G.R.S.

Action of ions and crystallographic conversions in reactions taking place in the solid state. J. A. HEDVALL, E. GARPING, N. LINDERKRANTZ, AND L. NELSON. *Z. anorg. allgem. Chem.*, **197**, 399–421 (1931); *Sprechsaal*, **65** [4], 65 (1932).—It was found that the capability of reacting is increased during a crystallographic conversion of a compound. A complete series of reactions of transformation were measured and relationships between the capability of reacting and electrical conductivity were studied. The action of ions is not necessarily a direct one. M.V.K.

The capability of reacting in the solid state and its dependence on factors of loosening up. J. A. HEDVALL. *Z. angew. Chem.*, **44**, 781–96 (1931); *Sprechsaal*, **65** [4], 65 (1932).—H. reviews researches on the capability of reacting in the solid state. The theory that every factor which decreases the rigidity of crystal lattices increases the interior mobility and with it the capability of reacting of the crystal was studied. The agents of loosening up are heat, crystallographic transformations, ionic deformation, intermixing constituents having a different lattice, and applied tensions and exposure to rays with suitable wave-length. The first four factors are discussed and explained by a series of examples. M.V.K.

Entropy, reversible processes, and thermocouples. E. H. KENNARD. *Proc. Nat. Acad. Sci.*, **18** [3], 237–41 (1932).—Attention is called to the fact that the statement frequently found in books that reversible processes never change the entropy of the universe is not strictly true unless the process is a reversible one. Two examples are considered. J.L.G.

Comments on the note by E. H. Kennard on "Entropy, reversible processes, and thermocouples." P. W. BRIDGMAN. *Proc. Nat. Acad. Sci.*, **18** [3], 242–45 (1932). J.L.G.

Silicate structures of the cristobalite type. II. The crystal structure of Na_2CaSiO_4. T. F. W. BARTH AND E. POSNJAK. *Z. Krist.*, **81** [5–6], 370–75 (1932).—In agreement with an earlier examination of the crystal structure of the isotropic compound Na_2CaSiO_4, it was found that the length of the edge of the unit cube containing four molecules of Na_2CaSiO_4 is $a_o = 7.48$Å; calculated density 2.80. The complete evaluation of the powder data results in the conclusion that Na_2CaSiO_4 has the space group $P2_14$ with 4Ca, 4Si, $4Na_I$, $4Na_{II}$, and $4O_I$ all in positions of 4f with parameters −2.5, 91, 180, 270, and 48°, respectively. The remaining $12O_{II}$ are in general positions with parameters $x = 200°$, $y = 240°$, and $z = 80°$. **III. Structural relationship of high-cristobalite α-carnegieite and Na_2CaSiO_4.** *Ibid.*, **81** [5–6], 376–85 (1932).—It is shown that α-carnegieite ($NaAlSiO_4$) and Na_2CaSiO_4, which from the chemical standpoint represent very different compounds, are structurally closely related and their structure is derived from one of the forms of silica, *i.e.*, high cristobalite. Further studies will show the existence of other silicates belonging to this series. It may be expected that other series of silicates, each structurally directly related to one of the many other modifications of silica, will be found. The structure of nephelite has been found to be closely related to the structure of tridymite. Such findings are the outgrowth of the work of W. L. Bragg (see *Ceram. Abs.*, **10** [7], 525 (1931)) who not only discovered what may be called the fundamental units of silicates, the silicon-oxygen tetrahedra, but found and called attention to the different ways in which these units are in some cases linked together. For Part I see *Ceram. Abs.*, **11** [5], 327 (1932). G.R.S.

Permanent changes in the optical orientation of feldspars exposed to heat. T. F. W. BARTH. *Norsk Geol. Tids.*, **12**, 57–72 (1932).—When orthoclase is heated the optic axial angle usually decreases slowly. In the case of adularia it took 450 hr. at

1000° to change the angle from 61 to 30°. The absolute amount of change depends on the composition, and usually the more K present the bigger the change. In all cases the position of the optic indicatrix remained unchanged. The optical properties of microcline are not changed by such heat treatment, and it does not invert to orthoclase. Except for a slight increase of the axial angle, the properties of albite and oligoclase are not changed on heating, but in labradorite an appreciable change of both position and shape of the optical indicatrix has been noted. When perthites are heated at 1000° diffusion occurs. A mixed crystal of apparently monoclinic symmetry develops on the contact between original albite and K phases. (*C.A.*)

Piperine as an immersion medium in sedimentary petrography. J. H. C. MARTENS. *Amer. Mineralogist*, **17** [5], 198–99 (1932).—Suggestions are given for methods of mounting mineral grains in piperine. The tendency to crystallize is prevented by heating the slide for one hour at 180°C. Advantages are made of the refractive index (1.68) and strong dispersion of piperine in mineral analyses. G.R.S.

Importance of the tension between glaze and body. OTTO LIEBELT. *Ziegelwelt*, **63**, 21–24 (1932); see also *Ceram. Abs.*, **10** [2], 127 (1931). (*C.A.*)

Quantitative determination of boric acid. II. Determination of boric acid in natural and artificial silicates. E. SCHULEK AND G. VASTAGH. *Z. anal. Chem.*, **87**, 165 (1932); for Part I see *Ceram. Abs.*, **10** [11], 811 (1931).

(*Trans. Ceram. Soc.* [Eng.])

Proof of the Gibbs hypothesis on the tendency toward statistical equilibrium. EBERHARD HOPF. *Proc. Nat. Acad. Sci.*, **18** [4], 333–40 (1932).—A mathematical proof is presented. J.L.G.

Isomorphous substitution of elements in minerals. A. H. PHILLIPS. *Amer. Mineralogist*, **17** [3], 85–93 (1932).—Volume is a prime factor in isomorphism, but there are other factors of equal importance even where the atoms are practically of the same size, such as (1) the coördinate position of the atom in the crystalline lattice, (2) atomic directional forces probably due to pressure, (3) the variable compressibility of the atoms, (4) differential expansion of the atoms with a rise of temperature, and (5) the weakening of the crystalline forces with a rise of temperature. G.R.S.

Melting points of zirconium and hafnium oxides. P. CLAUSING. *Z. anorg. allgem. Chem.*, **204** [1–2], 33–39 (1932).—A summary is given of many of the determinations of the melting points of these oxides as reported in the literature. There follows a description of the method by which C. determined these points. The melting temperature was measured by means of an optical pyrometer. The values of the determinations were ZrO_2 = 2950° ± 20°K; HfO_2 = 3047° ± 25°K. L.T.B.

Linear thermal expansion of muscovite mica. ANON. Bur. Stand. *Tech. News Bull.*, No. 181, p. 46 (1932).—The total linear expansion of preheated muscovite mica from room temperature to 900°C was found to be 0.73% resulting in a coefficient of 8.3×10^{-6}. The rate of expansion was unusually uniform throughout the entire range. The P.C.E. was 14 (equivalent to 1400°C). R.A.H.

Determination of fluoride by the calcium fluoride method. S. G. CLARKE AND W. N. BRADSHAW. *Analyst*, **57**, 138–44 (1932).—The quantitative precipitation of CaF_2 is discussed with regard to acid and neutral solutions, presence or absence of sulphates, and solutions containing borate. H.H.S.

Porosity of ceramic bodies. ANON. *Corriere Ceram.*, **13** [4], 127–29 (1932).—The boiling method for determining the porosity of ceramic bodies is discussed. M.V.K.

Volume weight of some materials. A. I. AVGUSTINIK AND A. G. FEIGELSON. *Ceramics & Glass*, **8** [2], 7–8 (1932).—A discussion of methods used for determining the volume weight of grog, quartz, sand, etc., is presented. M.V.K.

Quantitative separation of titanium from tantalum and niobium. W. R. SCHOELLER AND C. JAHN. *Analyst*, **57**, 72–78 (1932).—The oxalate-salicylate method for the separation of TiO_2 from the earth acids has been perfected. H.H.S.

Influence of the calcining temperature of kaolin on the color tone of ultramarine. P. P. BUDNIKOFF. *Jour. Applied Chem.* [U.S.S.R.], **4** [4], 458–40 (1931).—B. reviews the world literature on the chemical nature of ultramarine and phenomena influencing its color tone, and describes his own investigations the results of which are tabulated. It was found that (1) with increased calcining temperature of kaolin, the color tone of ultramarine changes from light blue to pure blue and then into a dull dark blue; (2) when replacing kaolin by pure alumina, the ultramarine obtained was of a beautiful dark blue color tone; when using an $Al_2O_3 + 2SiO_2$ mixture, the color tone obtained was greenish; (3) there is doubt that the coloring power of kaolin depends on its calcining temperature which is explained by the precipitation of anhydride of kaolin and

its separation into free oxides and the dispersed state of Al_2O_3 and SiO_2 (at about 900°). M.V.K.

Determination of silicic acid in apatites and phosphorites. V. E. TISHCHENKO AND M. M. RAINES. *Jour. Applied Chem.* [U.S.S.R.], **4** [4], 521–26 (1931).—The authors discuss the difficulty of determining silicic acid in minerals containing fluorspar and describe their researches. The method of Schrenk and Ode (*Ceram. Abs.*, **9** [7], 576 (1930)) was used. It was found that this method can be used with success for determining silicic acid in minerals containing fluorspar and is much simpler and more rapid than the method of Berzelius; also that chloric acid can be replaced by hydrochloric acid for the determination. M.V.K.

Statistics and ceramic research. J. ROBITSCHEK. Abstracted from *Zprávy Československ. keram. společnosti*, **8** [2], 120–27 (1931); *Sprechsaal*, **65** [18], 330–31 (1932).—The nature of raw materials used for the manufacture of ceramic products and the manner in which they are manufactured cause variations in the quantitative values of their physical properties. R. shows the importance of using the theory of distribution curves to obtain an idea about the properties of ceramic products and illustrates it by examples. The mathematical treatment of testing results permits conclusions to be drawn concerning the determination of properties. M.V.K.

Statistical methods of handling test results, with special reference to the testing of glassware. BERNARD P. DUDDING. *Pottery Gaz.*, **57** [659], 660 (1932).—The application of a mathematical theory to the results of tests of glassware is explained. E.J.V.

BOOKS

Chemical Arithmetic. S. B. ARENSON. v + 108 pp. Chapman and Hall, London, and J. Wiley and Sons, N. Y., 1931. Reviewed in *Chem. & Ind.*, **51** [19], 397 (1932). G.R.S.

Potentiometric Titrations: A Theoretical and Practical Treatise. I. M. KOLTHOFF AND N. H. FURMAN. Reviewed in *Chem. & Ind.*, **51** [19], 398–99 (1932); for abstract see *Ceram. Abs.*, **11** [5], 332 (1932). G.R.S.

Industrial Chemical Calculations: The Application of Physico-Chemical Principles and Data to Problems of Industry. O. A. HOUGEN AND K. M. WATSON. Reviewed in *Chem. & Ind.*, **51** [19], 396–97 (1932); see also *Ceram. Abs.*, **11** [5], 333 (1932). G.R.S.

Archive for Technical Measurements. (ATM, Archiv für Technische Messen.) Volume I, Nos. 1 to 3. GEORGE KEINATH. R. Oldenbourg, München and Berlin, 1931. 1.50 Rm. Reviewed in *Sprechsaal*, **65** [19], 362 (1932).—This work deals with different measuring methods and instruments. The following important methods connected with ceramics are discussed: (1) temperature measurements due to radiation, (2) thermoelements, (3) porcelain as industrial material, (4) porcelain condensers, (5) measurements of double refraction, (6) measurements of specific gravity, (7) optical testing of glass, and (8) polarization measurements. M.V.K.

PATENTS

Hydrated silica. S. S. SVENDSEN (Clay Reduction Co.). U. S. 1,859,998, May 24, 1932. The method of converting silica into hydrated silica which comprises heating silica to a bright red heat, suddenly cooling the silica, treating it with ammonium fluoride above 34 °C, and heating the mixture to volatilize ammonia silicon fluorine compounds therefrom, collecting the compounds, and treating them with water and ammonia below 34 °C, thereby transforming them into hydrated silica and ammonium fluoride.

Preparing stable selenium sulphide. B. W. NORDLANDER (General Electric Co.). U. S. 1,860,154 and 1,860,336, May 24, 1932. The method of producing stable, chemically active, selenium disulphide which comprises the steps of treating a solution of hydrogen sulphide in excess with selenious acid.

Manufacture of antimony compounds. CHEMISCHE FABRIK VORM. SANDOZ. Brit. 372,143, May 11, 1932.

General

Bureau of Standards' work in pottery industry. U. S. BUREAU OF STANDARDS. *Ceram. Ind.*, **18** [2], 99–103 (1932).—Research work done by the Bureau of Standards on the following problems is reviewed: (1) special "low-fire" whiteware bodies, (2) factors affecting the crazing of earthenware, (3) ceramic material of low thermal expansivity, (4) properties of china clays, (5) kaolins, effect of firing on physical properties,

(6) cutlery marking of chinaware, (7) gases evolved by feldspar, and (8) problems relating to saggers. W.W.M.

Value of grog in solving clay drying problems. BODIN AND GAILLARD. *Brit. Clayworker*, **40** [480], 12–14 (1932).—The effective drying of "London Clay" which is found in huge deposits around London, England, is described. This clay is highly plastic and yet is wanting in cohesion. With the use of fired clay grog, brick formerly taking 7 days to dry and with a production of at least 30% of defective ware can be safely dried under humidity controlled conditions in less than $1^1/_2$ days. The details of the experiments and the results are given. R.A.H.

Industrial roof maintenance. H. L. SCHULTZ. *Maintenance Eng.*, **90** [5], 197–99 (1932).—Types of industrial roofs, causes of roof troubles, and procedure and method of repair are outlined. A periodic roof inspection and the keeping of roof records are advocated. Illustrated. J.L.G.

Preventive maintenance of materials handling equipment in foundries. THOMAS A. BISSELL. *Maintenance Eng.*, **90** [5], 203–206 (1932).—Adequate maintenance of handling equipment may be obtained at a minimum cost by (1) maintaining a periodic and well-organized system of preventive inspection and service, and (2) using modern equipment designed especially to withstand the rigorous service of foundries. Illustrated. J.L.G.

Purification of factory smoke. ANON. *Giorn. chim. ind. applicata*, **14** [3], 151–52 (1932).—After many tests the following method for purifying factory smoke was adopted in Belgium: purification by electric precipitation, returning the smoke dust by gravity into the furnace for reburning, and utilization of the ash. The only residue eliminated contains about 1% carbon and can be used for the manufacture of light brick. The electric purifier used is an apparatus of Ostricourt-Parthenier which differs from others in that it has a metallic screen with 2 cm. mesh stretched parallel with the electrodes at a distance of 3 cm. from them. Notable results have been obtained with this system at the Farciennes plant in Hainaut. M.V.K.

Kutahia, the ceramic center of modern Turkey. R. DE BLOTTEFIÈRE. *Corriere Ceram.*, **12** [12], 497–503 (1931); **13** [2], 69–75; [4], 133–39 (1932).—The location and railroad communications of the region of Kutahia and the abundance of raw materials used in the refractory, majolica, whiteware, stoneware, and brick industries in its vicinity make it the center of the ceramic industry in Turkey. There is a great need for modernization of the plants and methods of manufacture. M.V.K.

Importance of trade names. ANON. *Brit. Clayworker*, **40** [480], 15 (1932).—If a firm has a valuable asset in brick or other articles of a distinctive type, it should register a name or "brand" for them as otherwise it may shortly find itself in serious competition with other firms who have seized upon the idea and are making full use of it. The advantages of a trade name in addition to a patent are discussed. R.A.H.

1930 British census of production. ANON. *Times Eng. Supp.*, **29**, 572 (1932).—The preliminary report of the 1930 census is better than was anticipated, compared with 1924. There was a greater weight of production in most branches of pottery. The gross output was £13.7 million, against £17.4 million in 1924; and the average number of employed was 66,118 against 69,402. H.H.S.

BOOKS

Gems and Gem Materials. E. H. KRAUS AND E. F. HOLDEN. 2d ed. x + 260 pp. McGraw-Hill Book Co., New York, 1931. Price $3.00. Reviewed in *Amer. Mineralogist*, **17** [3], 124 (1932). G.R.S.

Flotation. Chemistry and Present-Day Technique. (Flotation. Chemie und Technik der Gegenwart.) E. W. MAYER AND H. SCHRANZ. S. Hirzel, Leipzig, Germany. 593 pp. Paper, 33 Rm., cloth, 35 Rm. *Mining & Met.*, **13** [305], 255 (1932).—A comprehensive account of the theory and practice of flotation, with emphasis upon European applications and experiences, is presented. Lists of German patents on flotation, of European flotation plants, and of the minerals that can be treated by flotation are given. E.J.V.

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Book Review

Raw Materials for Porcelain-Earthenware Manufacture. S. I. NAZAREVITCH. State Scientific-Technical Publishing House, Moscow and Leningrad, 1931. 30 pp. Price 40K. This brochure deals with the primary and secondary kaolins, plastic and refractory clays, fluxes, and grog materials. Gypsum for casting of molds, lining materials, and balls for ball mills are described. S.I.PERKAL

PATENTS

Ceramic character or symbol. W. O. PROUTY (Metlox Corp., Ltd.). U. S. 1,859,792, May 24, 1932.

Processes and devices for the treatment in a dry way of earths containing kaolin. E. SOYEZ AND M. CHEROUVRIER. Brit. 372,648, May 19, 1932.

Wet purification of clays and other earths or rocks. F. PARENTANI. Belg. 380,676, July 31, 1931. A suspension of clay in water is subjected to vacuum before treatment with H_2S gas in order to remove occluded air. Reoxidation of the sulphides during treatment with H_2S is thus prevented. The foam which forms at the surface of the liquid during the application of vacuum is broken by means of an agitator. (*C.A.*)

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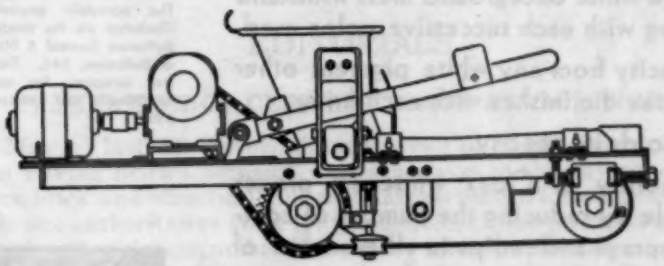

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of the

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A Monthly Publication Devoted to Proceedings of the Society, Discussions of Plant Problems, Discussions of Technical, Scientific, and Art Questions, and Promotion of Coöperative Research

Edited by the Secretary of the Society Assisted by Officers of the Industrial Divisions

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EDITORIALS

FEDERATION OF CERAMIC TRADE ASSOCIATIONS

On May 11 last, in Cleveland, on the call of O. W. Renkert, Metropolitan Paving Brick Company, representatives of the paving, common, and face brick and structural tile associations met to form a federation to provide one authoritative voice for the structural clay products industries in matters of legislation, and in other fields where problems are met which are common to all producers of structural clay products. This meeting was followed by a meeting of the secretaries of these four associations in Chicago on May 20. Thus the ground work was laid for a united and cooperative development and promotion of structural clay products.

Under the camouflage of conserving the timber resources of the nation, some twenty-odd associations interested in wood products federated in support of what is known as the "Wood Utilization Committee." This committee has offices in the U. S. Department of Commerce. Its engineers have semifederal status and the right of way in the several bureaus and governmental offices. Its reports and books are printed by the government. It has postal franking privileges, it has flooded the country with literature favoring wood for all sorts of purposes, including buildings, and it has engaged in far-flung publicity in national magazines. We cite this as the extent to which a federation of ceramic associations can go in the promotion of their mutual welfare. We can not agree that the Wood

Utilization Committee has the right of office space, federal recognition, and printing and mailing privileges financed by the government. We do, however, admire the nerve and the ingenuity that have gained these privileges for the Wood Utilization Committee, and incidentally for the several wood trade associations which federated in support of the Committee.

There are legislations constantly before our several state legislative bodies, and there are rules and regulations being formulated by our federal departments which are inimical to ceramic products. No one industrial group in a state or in the nation has the influence to prevent such legislative acts, but experience in Ohio has proved that when our ceramic industries join in protest, the interests of ceramic products are protected.

Protection against legislative acts is important, but it is one of the lesser benefits of the federation of trade associations. The larger benefits come in the promotion of ceramic products. There is a legitimate place and use for each of the several structural ceramic products. Many manufacturers produce all sorts of brick, structural tile, and terra cotta. There is no room for defeating competition and vitriolic disparagement of other products; there are, however, many advantages in a united approach to the architects, contractors, and builders in the interest of whatever product serves best in each particular instance.

With the engineers and architects in the making in our several universities, there is a large opportunity to make mindful all of the superior qualities of ceramic structural materials by those who are to be the purchasers in the immediate future. The problems of economical construction, reinforced clay product masonry, and other such problems should be studied by our universities under highly specialized engineering advisement with the purpose of obtaining data for incorporation in the standard data books used by the engineers and architects, and for the purpose of making the young engineers and architects ceramic-product minded.

There are many ways in which ceramic materials can be improved, and the cost of production lessened. The lessons from the kiln studies financed by the four structural clay products associations, and later independently by the Refractories Association, were learned and put into effect by very few. There is still an enormous waste in connection with the firing of ceramic products.

The recent development of vacuum treatment of stiff-mud and dry-press process for brick manufacture should be credited directly to the results obtained through coöperative support of researches instigated by the Ohio Ceramic Industries Association and conducted by the Ohio State University Engineering Experiment Station at the Roseville prison brick plant. These were large scale experiments which no private company could afford to make, not altogether because of the prohibitive expense, but because of the facilities required. Opportunities for similar cooperative work can be found in nearly all of the industrial states. Ohio has the set-up and the capacity for a large increase in such coöperative studies which would lead directly to better products at less cost.

It is to be hoped that other associations will eventually join with the structural clay products associations in a federation. Those of us who are so positioned as to see the vast overlap in the several interests of manufacturers ranging from brick to the finest of glass and enamel ware can see

the advantage of a wide extension of the federation which O. W. Renkert has succeeded in making with the strictly structural clay associations.

Mr. Renkert deserves honorable recognition for this very excellent service which he has rendered to the ceramic industries. It has taken years of effort and a consideration of many proposals. It is a matter of large concern that Mr. Renkert has succeeded in laying the groundwork for what will eventually be a ceramic federation that will result in better quality at lower costs and with larger use of ceramic products.

In this connection the untiring efforts of J. L. Murphy are recalled. Mr. Renkert would be among the first to credit the late Mr. Murphy with a great deal of the success that has finally crowned the efforts of Murphy and Renkert.

PROMOTION OF CERAMIC PRODUCTS

Nonceramic products are crowding the several fields which once were exclusively enjoyed by ceramic products.

No longer is building material restricted to wood, stone, brick, and concrete. No longer is our artware confined to clay, glass, and cloisonné. For the table we are offered products other than clay and glass.

It requires constant vigilance to keep the purchasing public conscious of the availability and the superiority of a given product. It requires constant educational effort to keep before the retail buyers and the ultimate consumers the fact that in America there is produced ceramic products for all purposes that have no superior abroad. It was a shock to our potters, to the pottery dealers, and to the public at large to learn that in America there were ten potters equipped, well qualified, and experienced in making copper plate underglaze decorated souvenir plates at prices comparable to any quoted from abroad. Because Lenox is a name that has become widely known, it is surprising how many well educated and far traveled people have the notion that Lenox is a foreign-made product. They are surprised when they learn that it is made in Trenton, N. J., and that similar ware has from time to time been produced in other places in the United States.

Very few people know that the spark plug, high-tension porcelain, heat-resistant glass, the modern sanitary ware, the modern terra cotta, the artificial abrasive wheels, the silicon carbide and mullite refractories, and many other well-known ceramic products were first developed in this country. America leads in technical and scientific education and development, and is among the leading countries in ceramic art. American citizens should be made conscious of these facts.

America's ceramic artware, ceramic enamel ware, glassware, and clayware of all sorts are of high quality and have no superior. The porous tableware usually spoken of as earthenware or semiporcelain made in America and sold most largely through the chain stores is equal in all respects to the earthenware for which England and other countries are justly famous. Our vitreous china has no superior. The fact that America does not have pottery a century old and the fact that our producers are not manufacturing under firm names to be found on costly antiques is no argument against the high quality and serviceability of American-made products.

Justly proud though we might be, the fact remains that producers of comparable products are more alert in educating the public, are more active in national magazine publicity, and are creating a larger demand for their products.

If ceramic products are to have and to hold their just share of the trade in the several fields which they once enjoyed exclusively, the ceramic ware producers must be more actively engaged in publicity and other promotional enterprises.

PAPERS AND DISCUSSIONS

REPORT OF THE CAST-IRON RESEARCH COMMITTEE OF THE ENAMEL DIVISION*

This investigation on the blistering of enamels on cast iron was initiated by the Research Committee about seven years ago. Interested manufacturers connected with the AMERICAN CERAMIC SOCIETY donated the sum of $1500 for the purchase of materials, and the aid of the Bureau of Standards was enlisted. The Bureau worked for three years on the problem and published the results.[1] With only $800 of the Committee fund remaining, it was decided to discontinue the investigation temporarily.

The Committee felt that if sufficient samples of blistering iron could be obtained from different sources, with complete information as to their history, some significant conclusions might be drawn.

The services of E. P. Poste, who was thoroughly familiar with the investigation since its inception, were secured at this time. Mr. Poste's report, which follows, more than justifies this action. While coöperation of the enamelers in general in furnishing samples was not what was anticipated, the specimens were excellent and were accompanied by a complete history of the case. The work will be continued with the funds available and there is still an opportunity to submit samples for study.

The Committee wishes to take this opportunity to thank those who have coöperated.

Respectfully submitted,

R. R. DANIELSON, *General Chairman*,
Research Committee, Enamel Division
M. E. MANSON, *Chairman*,
Sub-Committee on Cast-Iron Research

THE BLISTERING OF CAST-IRON ENAMEL: PROGRESS REPORT

BY EMERSON P. POSTE

I. Introduction

Samples of cast iron have been received from a number of plants having blistering trouble. These samples were studied as to foundry history, composition, behavior on enameling, and metallographic structure, to derive information as to the cause and cure of the type of blistering seeming to come from sources other than those definitely related to physical defects in the castings such as porosity and the obvious presence of slag and other foreign material. The program of research is obviously incomplete and the data at present available are insufficient to make possible more than certain suggestions as to indicated conclusions. Only such portions of the records are covered in this report as seem essential to clear presentation of the progress made.

II. Foundry Practice

Cupola charges ranged from 12.5% pig and 87.5% scrap to 100% pig and no scrap. Foundry scrap varied from 35 to 54%; foreign scrap from 10 to 50%; steel scrap from none to 21%. One foundry reported

* This is a Progress Report of work done during the year, 1931, on "Blistering of Enamels on Cast Iron" by E. P. Poste. Received April 28, 1932.

[1] "Progress Report on Cast Iron for Enameling Purposes," *Jour. Amer. Ceram. Soc.*, **11** [8], 595 (1928); "Blistering Phenomena in the Enameling of Cast Iron," Bur. Stand., *Jour. Research*, **4**, 757 [Research Paper No. 129] (1930).

the blending of three pigs; several used two pigs and others only one. In many cases close watch of pig composition is practiced while in others no particular attention was paid. One case involved the use of a pig taken to contain 2.45% Si and 0.67% P, and analysis of the pig revealed 2.67% Si and 0.88% phosphorus. Reported amounts of limestone flux ranged from 1.0 to 5.3%. One foundry reported the use of a high flux which is known to be high in magnesium. This is generally accepted as poor practice due to the high viscosity of magnesium slags. Limestone is often specified to contain not less than 85% calcium carbonate.

The cupolas involved ranged from 32 to 68 inches in diameter and the melting ratios from 6.3:1 to 11:1. In one case a special de-sulphurizing process was in use.

III. Composition of Iron

All samples of iron were analyzed as received. To note any possible relation between composition and blistering, the irons submitted as nonblistering and blistering were averaged in separate groups with the results found in Table I.

TABLE I

AVERAGE COMPOSITION OF CAST IRONS FOR WET-PROCESS ENAMELING

	Si	S	P	Mn	TC	"FeO"
Nonblistering						
Highest	2.90	0.082	0 94	0.65	3.38	0.32
Average	2.64	0.075	0.70	0.52	3.30	0.28
Lowest	2.51	0.065	0.20	0.47	3.25	0.22
Blistering						
Highest	2.60	0.104	0.86	0.60	3.57	0.36
Average	2.30	0.086	0.69	0.49	3.48	0.28
Lowest	1.92	0.058	0.13	0.37	3.40	0.22

NOTE: The column headed "FeO" refers to determinations for ferrous oxide made by the iodine-solution method. This is not thought to be accurate for ferrous oxide alone, other materials probably being insoluble in iodine under conditions of the determination. But certain field data from outside sources had indicated a possible relation between blistering and the results of this determination; hence the advisability of including it in the investigation.

The data suggest that the irons lower in silicon and higher in total carbon were more prone to blister. The higher sulphur of the blistering iron may be worthy of note. Figures for phosphorus, manganese, and "ferrous oxide" suggest nothing.

IV. Surface Layer

The Bureau of Standards[3] attributed blistering to a surface "microchill" and gave data to show certain differences in composition between the surface and the interior.

The surface and shape of castings received in this investigation were such as to make removal of a thin surface layer impossible without contamination by iron below the surface. The average of figures actually obtained is given to indicate qualitatively such differences as might be present. More accurate data for a given case were submitted with one

[3] Bur. Stand., Research Paper, No. 179, p. 784.

set of castings and the figures are recorded as "Special Case." Table II includes the essential determinations.

TABLE II

RELATIVE COMPOSITION OF SURFACE LAYER AND INTERIOR

General Average	Si	S	P	Mn	TC	GC	"FeO"	CC
Surface	2.37	0.110	0.41	0.37	2.57	1.87	0.15	0.70
Interior	2.34	0.103	0.44	0.49	3.28	2.58	0.14	0.70
Special Case								
Surface	2.53	0.088	0.13	0.51			0.08	0.82
Interior	2.41	0.079	0.15	0.64			0.06	0.40

The differences in composition between surface and interior are in the same direction as found by the Bureau for sulphur, manganese, and total carbon, while the reverse is true for silicon.

Additional data submitted from another laboratory show silicon at the surface to be higher in some cases, lower in others.

V. Relation between "Expected" and "Found" Compositions

Because the blistering and nonblistering irons gave different average compositions, data were studied to see whether compositions submitted with samples were in line with those obtained on actual analysis. All of the compositions as submitted were averaged and like values for actual analyses of the corresponding irons were also compiled. The results are given in Table III.

TABLE III

RELATION BETWEEN "EXPECTED" AND "FOUND" COMPOSITIONS

	Si	S	P	Mn
Average "expected"	2.46	0.088	0.54	0.51
Average "found"	2.39	0.094	0.60	0.48
Average difference	−0.07	+0.006	+0.06	−0.03
Max. over	0.15	0.029	0.24	0.03
Max. under	0.30	0.013	0.08	0.18

While the difference between "expected" and "found" values is insignificant in every case, the maximum variations for each determination are of sufficient magnitude to be of importance, particularly with reference to silicon, in which case the maximum variation from average "found" is practically the same as the difference between the averages for nonblistering and blistering iron shown in Table I. Though data for total carbon are not available, it may be assumed that a corresponding difference existed.

If the relative figures in Table I are of any significance they indicate that close attention to silicon content is required. It is further probable that, in a given foundry, the other elements should be held within closer range than the extremes shown in Table III to assure proper uniformity of iron with reference to characteristics other than blistering tendency.

VI. Experimental Methods

In connection with many of the irons submitted experimental enameling tests were made. The majority of the work was done in a laboratory electric furnace. A few heats were made in an industrial furnace.

The majority of the cases investigated involved wet-process enameling. There were, however, enough samples of dry-process iron to warrant an effort to establish a relation between the two methods as to blistering.

Several dry-process samples, apparently satisfactorily enameled, were found to exhibit a layer of enclosed bubbles near the iron, especially on iron which blistered badly by the wet process. Samples of blistering iron with a part of the surface layer removed by grinding or machining, followed by dry-process enameling, showed more of these concealed bubbles on the unground portion than on areas from which the surface had been removed.

These observations led to the use of the wet process for the majority of the experimental work.

The next requirement was the choice of an enamel to use as an index of blistering. It was presumed that enamels in commercial use at the plants submitting samples were, of themselves, relatively free from blistering tendencies. An experimental enamel known to have a definite tendency to blister on slightly blistering irons became available. Its relation to a good commercial enamel as to blistering was established experimentally. A commercial enamel used was designated "regular" and an experimental blistering enamel as "special."

The following terminology has been used: (1) OK, no blistering; (2) S, slight blistering, barely detectable; (3) D, definite (enough to cause probable rejection of ware); (4) B, bad (blistering quite general and in large areas); (5) VB, very bad (bad blisters over most of piece).

Two types of blistering have been taken into consideration: general blistering over large areas, possibly related to the iron as a whole, and local blistering, confined to small areas and probably related to segregations in the iron.

An effort has been made to disregard any blisters definitely due to physical defects in castings.

VII. Removal of Surface Layer

In general the removal of the surface layer, either by machining or grinding prior to enameling, has eliminated blistering. A few irons have blistered less after surface removal while a few have shown no apparent benefit from this treatment. These observations suggest that the microchill may have a very important bearing on most blistering but that other factors must be involved, at least in certain cases.

VIII. "Manson Effect"

A phenomenon initially pointed out by M. E. Manson has been termed the "Manson effect." It is essentially a more or less violent "boiling" taking place when heated cast iron is dredged with a small amount of enamel which is allowed to fuse down from heat in the casting without addition of more enamel. It is more pronounced when a casting is heated to 1650°F without ground coat and given a light sprinkling of enamel, dredging ceasing when just enough enamel is present to form a thin coat. Under ordinary processing this effect goes by unnoticed and possibly causes weakness of enamel due to concealed bubbles near the metal, or surface defects in the form of blisters or collapsed bubbles. This tendency is much more pronounced with irons known to blister badly on wet-process enameling, and the removal of the surface layer has served to eliminate the trouble in most cases. Mr. Manson believes that this

phenomenon is definitely involved with blistering, possibly through chemical reaction between enamel and surface layer.

In this investigation the "Manson effect" was roughly proportional to the blistering tendency by the wet process.

The "Manson effect" might be caused by (1) some behavior of the enamel upon striking a hot surface, (2) some chemical reaction between the enamel and the metal, a product of which is a gas, or (3) the passage of gases from within the metal out through the enamel.

To investigate the first possibility, enamel has been dredged on platinum under the essential heat conditions of dry-process enameling with no disturbance whatever.

In some cases the "Manson effect" is not the result of reaction between the surface of the iron and enamel for in some of the most pronounced cases of this type of boiling, metal well within the original casting was involved.

IX. Selected Cases of Trouble

A few typical cases have been selected from those submitted to illustrate the variety of conditions involved and to bring out certain facts for later consideration. For convenience these are lettered to facilitate references.

Case A Satisfactory experience was obtained with a standard brand of coke, sand-cast pig, no steel scrap, iron averaging 2.70% silicon and 3.40% total carbon. At a given time the practice was changed to cheaper grade of coke, sand-cast pig, and steel scrap, with iron averaging 2.40% silicon and 3.55% total carbon. Blistering gradually appeared, finally becoming so bad as practically to stop production. The new pig iron was found to contain a large proportion of pieces with porous and hollow centers lined with black crystalline material. Drillings from the spongy portion were high in silicon and total carbon. A change back to standard coke and sound machine cast pig and the discontinuing of steel scrap, with the resulting iron averaging 2.55% silicon and 3.30% total carbon, caused the trouble to disappear.

Case B A shop running four cupolas had varying qualities of iron from the several cupolas. A 60-inch unit using 45% foundry scrap, melting ratio 11:1, melting 13 tons per hour, with an average composition of 2.85% silicon, 3.50% total carbon, and 0.50% phosphorus made good iron as to blistering. Another cupola, 32 inches in diameter, running on 42% foundry scrap, 21% steel rails, melting ratio 6.3:1, melting $2^1/_2$ tons per hour, gave an iron averaging 2.40% silicon, 3.45% total carbon, and 0.15% phosphorus. Iron from this unit blistered badly.

Case C A jobbing shop doing stove-parts enameling had a satisfactory experience with iron from one source and blistering with another iron. The good iron came from a foundry using 50% foundry scrap, $1^1/_2$% limestone, and producing an iron averaging 2.60% silicon, and 3.30% total carbon. The poor iron came from a foundry for which melting practice data were not available. The composition ran 1.95% silicon and 3.55% total carbon. Samples of both irons were received. The iron submitted as good enameled well while that said to be bad blistered on repeated enameling and even with the surface layer removed.

Case D In a dry-process shop blistering was local rather than general. Samples submitted indicated blistering on a small area in a bath tub, the remainder of the surface being good. In the cupola 35% foundry scrap and $27^1/_2$% stove plate scrap were being used. The iron contained 2.20% silicon and 3.53% total carbon. There was no material difference in composition between good and bad areas. Samples enameled experimentally with wet-process enamel blistered in the reverse order as compared with the original dry-process trouble. The iron had been enameled before, however, it being impossible to tell in advance where blistering might take place.

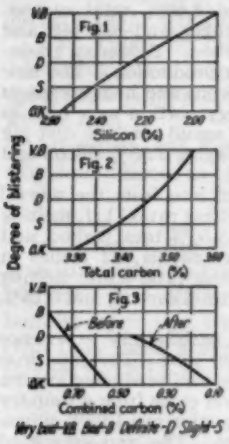
Case E The most extreme case observed involved stove castings which as a whole enameled well but frequently showed small spots of intense blistering which developed on both sides of the casting and repeated in the same location on re-enameling. This iron came from a 68-inch cupola using 52% foundry scrap, 8% steel scrap in the form of "bundle" scrap, and 5% limestone known to be high in magnesia. The melting ratio was $8^1/_2$:1 and the iron contained 2.25% silicon and 3.45% total carbon. Previously

enameled castings which had blistered locally on both sides blistered on repeated re-enameling experimentally. Some of the unenameled castings submitted were found to contain hard spots high in combined carbon (white iron).

Case F Experience at one plant had led to the theory that a given iron would blister worse when cast in thicker sections. Foundry practice involved the use of a high total scrap percentage including both foundry and stove plate stock. The composition intended was 2.30% silicon, 0.110% sulphur, 0.60% phosphorus, 0.35% manganese, and 3.20% total carbon. Samples submitted ran about 10 points lower in silicon, but otherwise they were as expected. Samples $^1/_8$, $^1/_4$, and $^1/_2$ inch thick from the same iron, enameled when received, indicated progressively more blistering with increased thickness. Samples of raw iron all poured from the same ladle of iron, enameled experimentally in connection with this investigation, confirmed the observation. Thinking that the difference in thickness of the samples as affecting the firing cycle might have a bearing on the problem, a piece of the $^1/_2$-inch casting was machined to a thickness of $^1/_8$ inch by removing stock from the cope side. This and a piece of the original $^1/_2$-inch casting were enameled under uniform conditions, with enamel applied to the drag surface, and the piece from the original $^1/_2$-inch casting blistered as badly as before. These observations were checked and the conclusion reached that (at least with this particular iron) thicker castings were more prone to blister.

X. Suggested Relations between Silicon, Carbon, and Blistering

Figure 1 indicates the relation between blistering and silicon content, Fig. 2 corresponding observations for blistering and total carbon, while Fig. 3, based on less extensive data, suggests a relation between blistering and combined carbon, before and after enameling. While all of the data plotted are not closely in line with the graphs, the tendencies are definite enough to warrant the presentation as made.



FIGS. 1–3.

The castings involved were from various sources and of many variations in design. Studies on the relation between thickness of iron as cast and blistering of enamel as covered in Case F afforded data for irons of the same origin processed under uniform laboratory conditions. Relations between combined carbon after enameling and degree of blistering in four separate cases are plotted in Fig. 4, which also includes what may be taken as an average graph for the four cases as a whole. This bears an interesting relation to the corresponding graph on Fig. 3. The irons involved in Fig. 4 were more inclined to blister than those in Fig. 3, hence the graph is higher with reference to degree of blistering.

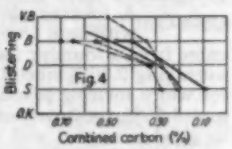


FIG. 4.

XI. Metallographic and Related Observations

Certain of the samples having particular importance were submitted to Geo. F. Comstock, Titanium Alloy Mfg. Co., for metallographic study. The major findings of Mr. Comstock are presented along with other data that are definitely related thereto. The samples involved originated with the "selected cases of trouble" previously referred to (see p. 205).

Case C Iron that blistered on enameling. The structure of the unetched specimen is shown in Fig. 5. The important feature is the presence of "gray oxide films, penetrating irregularly into the iron from the edge that had been enameled." The microstructure after etching is seen in Fig. 6. The predominance of ferrite is in line with the analysis which shows the combined carbon after enameling to be 0.20%.

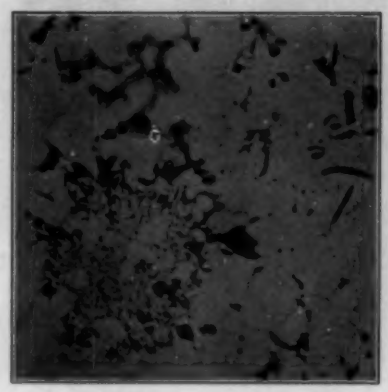


FIG. 5.—Case C: Irregular streaks of gray oxide above middle; black spots are graphite and faint irregular areas in relief in background are steadite (phosphide eutectic) (200 ×, unetched).

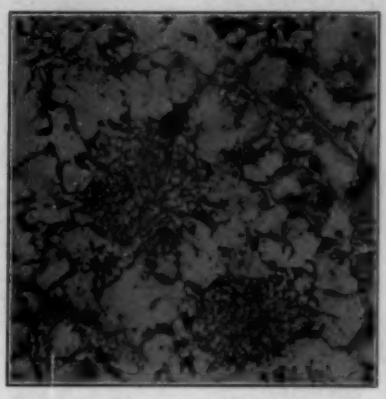


FIG. 6.—Case C: Average structure near edge of section; black spots are graphite, and irregular spotted areas steadite; bright background is ferrite, shading into pearlite or sorbite near steadite areas (200 ×, etched with picric acid).

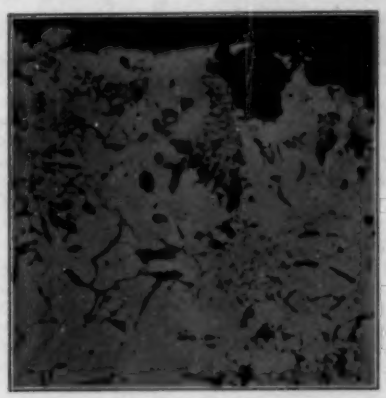


FIG. 7.—Case D: From portion that enameled well; very rough edge with particles of enamel, slag, and sand adhering, and thin streaks of oxide near middle and a little above (100 ×, unetched).

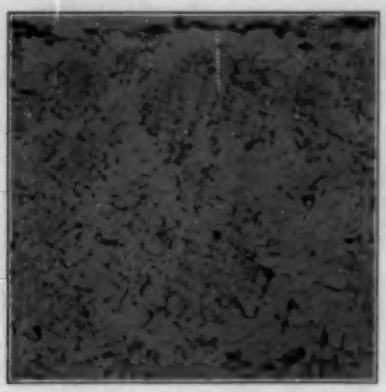


FIG. 8.—Case D: From portion that blistered; clean and even edge of section, with very fine-grained iron; bright strip at extreme top is copper strip to protect edge in polishing (100 ×, unetched).

Case D At the portion of the tub which had enameled well the iron was about $^{1}/_{16}$ inch thick. The unetched specimen indicated a rather coarse structure with definite oxide films penetrating in from the edge (Fig. 7). At the blistered area the

iron was thinner, less than 1/4 inch thick. The unetched structure was very fine making the detection of possible oxide films difficult though some are suggested. Figure 8 shows the structure, in definite contrast to that in Fig. 7. The marked difference in fineness of structure in these two areas is worthy of special note.

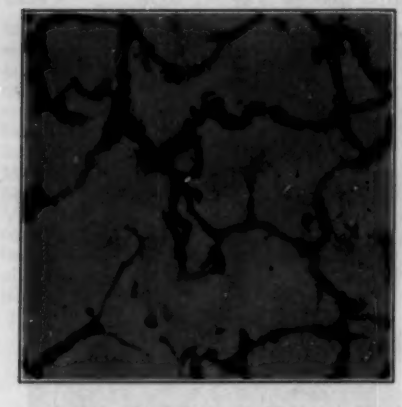


FIG. 9.—Case E: Oxidized area at middle of section where enamel blistered; curved gray streaks are oxide; black spots graphite; very little steadite shown (500 ×, unetched).

FIG. 10.—Case E: Oxidized area at edge of section where enamel blistered; most of structure is pearlitic, except where gray oxide streaks penetrated, producing abundance of bright ferrite (100 ×, etched with picric acid).

Case E The sample investigated had been enameled, developing a local blistering of severe intensity. Examination at portions which had not blistered indicated a medium fine structure, chiefly pearlitic, with traces of oxide near the surface. Iron beneath the blistered enamel showed an entirely different condition. "There was a very marked penetration of irregular oxide streaks. . . . not only prominent at the edge of the section but also in several spots near the center, about midway between the two surfaces of the casting." Figure 9 is a striking illustration of this, unetched and at relatively high magnification. "The iron where the oxide streaks occurred was chiefly ferrite, indicating that the carbon had been removed, and the gas formed in its removal was probably the cause of the blistering." Figure 10 brings out these facts and indicates that the matrix in general is pearlitic. This is in accord with the fact that the combined carbon after enameling was found to be 0.51%.

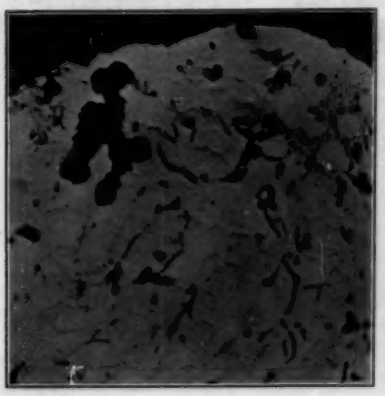


FIG. 11.—Case F: From sample cast 1/8 inch thick, showing slag inclusion near edge in upper left corner and trace of scale at edge; graphite and steadite appear as before (200 ×, unetched).

Case F The samples used in comparing the enameling behavior of 1/8-inch iron cast as such and that cast as 1/2 inch, machined to 1/8 inch, afforded valuable metallographic and analytical data. Figure 11 shows the unenameled iron unetched. Some slag is indicated but no definite signs of oxides were noted. Upon etching, the structure proved to be pearlitic. After enameling, this iron showed essentially the same structure unetched. The etched specimen showed the presence of considerable ferrite and correspondingly less pearlite. "The edge of this section next to the enamel was slightly

decarburized, with traces of oxide. No deep penetration of oxide was found." Figure 12 substantiates these observations. The large bubble in the enamel may have come from a damage to the surface before enameling, causing the distortion of structure shown immediately beneath. This iron blistered but slightly. The combined carbon dropped from 0.73 to 0.28% by the heat of enameling, in line with the decrease in pearlite and increase in ferrite.

The corresponding observations for the 1/8-inch iron, machined down from the 1/2-inch casting, offer interesting differences. The unetched specimen showed a coarser structure with frequent penetration of oxide as shown in Fig. 13. Etching revealed but little ferrite. After enameling, this iron had the etched structure of Fig. 14. "The edge of this section near the enamel is deeply oxidized at numerous points." The internal structure is essentially the same as before enameling, largely pearlitic. "At the oxidized places near the edge, however, there was an excess of ferrite, with distinct irregular streaks of

FIG. 12.—Case F: From sample cast 1/8 inch thick; enamel with large bubble above, fine-grained iron below, with considerable bright ferrite, as well as gray pearlite, black graphite, and bright irregular steadite; structure just below bubble is distorted (100 X, etched with picric acid).

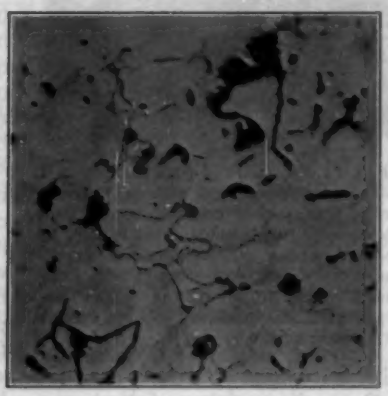


FIG. 13.—Case F: From sample cast 1/2 inch thick showing thin gray streaks of oxide near middle; graphite and steadite shown as above (200 X, unetched).

oxide penetrating the iron. . . ." This sample had blistered badly. The heat of enameling caused the combined carbon to drop from 0.70 to 0.55%, much less than in the former case, and in line with the metallographic observations.

A casting used for experimental enameling and not related to any of the cases mentioned above is worthy of notice. It was 1/2 in. thick as enameled but had been machined from a larger casting. The structure was very coarse, showing no oxide. The unetched specimen is shown in Fig. 15, and the etched in Fig. 16, both after enameling. The casting blistered badly and showed a drop in combined carbon of from 0.75 to 0.67%, the latter figure being entirely consistent with the pearlitic structure shown in Fig. 16. Only a small amount of ferrite is evident.

In summarizing his report Mr. Comstock states that "without much doubt... oxide streaks penetrating within the iron are a cause of blistering...." He goes on to say that not all of the cases under observation can be explained in that way. He refers particularly to Case D and the isolated 1/2-inch casting following Case F immediately above. "It seems that there must be other causes of blistering besides oxide penetration; and of course evolution of gases or delayed evolution, to which blistering is evidently due, may be accounted for in more than one way. The gases may be pro-

FIG. 14.—Case F: From sample cast 1/2 inch thick showing normal enamel above, and rather coarse-grained iron below, with not much ferrite except in oxidized areas where steadite is replaced by irregular streaks of gray oxide; such areas are at upper left corner and near middle (100 ×, etched with picric acid).

duced by oxidizing reactions in some instances, or may be absorbed reducing gases in others...." "...previous occasional examinations of defective enameled cast iron in our laboratory have indicated that blistering is often associated with internal oxidation of the iron, or with coarse graphite, but a single definite cause for all blistering has not been found by metallographic examination."

XII. Blistering and Rate of Annealing

A review of the data up to this point suggested that irons which were slow in annealing were prone to blister. The term "annealing" is taken to mean the structural change from pearlite to ferrite and free carbon. The question arose as to whether the rate of annealing in terms of the heat of enameling might have a bearing on blistering.

Three irons were chosen for experimental study: (*a*) a heat-resisting cast iron of special composition, pearlitic in structure; (*b*) iron from Case F which had shown relatively high combined carbon after enameling, accompanied by bad blistering; and (*c*) iron from Case E which had enameled with but slight blistering and with relatively low final combined carbon.

Enameling of iron (*a*) at normal cycle developed bad blistering with

FIG. 15.—Sample from large casting: Enamel at top and very coarse-grained iron, without any oxide at or near edge (100 ×, unetched).

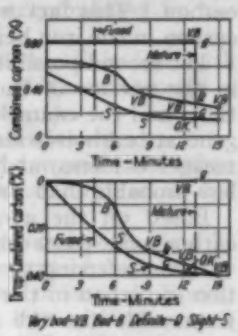
FIG. 16.—Sample from large casting: Typical interior structure, consisting chiefly of coarsely lamellar pearlite; black graphite and bright ferrite also shown (200 ×, etched with picric acid).

both regular and special enamel and produced the most pronounced "Manson effect" of any iron tested. The removal of the surface layer made no apparent improvement. It was assumed that bad blistering would have existed at any intermediate stage of firing between initial softening and final maturity.

Samples of irons (*b*) and (*c*) were fired for periods ranging from 3 to 15 minutes and the final combined carbon determined in each sample. The blistering was noted, that of the normally fired pieces checking as to degree with previous samples of the same irons.

There was some difference in the initial combined carbon in the several pieces of iron (*c*). Taking this into account, the corrected combined carbon after enameling is shown in Fig. 17 and the amount of annealing as indicated by drop in combined carbon gives the curve in Fig. 18. In either case vertical lines indicate the points of first fusion and normal firing, respectively. The degree of blistering is expressed by letters per notation previously used.

These tests may be taken to indicate that annealing at early stages of the firing is accompanied by a minimum amount of blistering while, at the other extreme, iron showing no annealing blisters most severely.



FIGS. 17–18.

XIII. Summary

Available data based only on work covered by this report may be reduced to several rather definite statements:

(1) Blistering of wet-process cast-iron enamels will more likely occur on irons low in silicon and high in combined carbon than on those of the reverse nature.

(2) Irons high in initial combined carbon are more liable to blister than those of lower combined carbon content.

(3) Irons that anneal to a relatively low final combined carbon content blister less than those annealing to a lesser degree.

(4) Blistering is less pronounced with irons which anneal rapidly during the early stages of firing.

(5) Irons which retain a pearlitic structure after enameling are more inclined to blister than irons that do not resist annealing.

(6) In the majority of cases the removal of the surface layer eliminates or greatly reduces blistering, though in some instances no benefit seems to be derived. This apparently applies to irons that resist annealing.

(7) At least with certain irons castings of relatively thick section tend to blister more than the same irons cast in thinner sections.

(8) Light dusting of iron with dry-process enamel at 1650°F develops a more or less violent bubbling on most irons. Those which exhibit this tendency to a marked degree also blister on wet-process enameling.

(9) The presence of intergranular iron oxide as revealed by metallographic methods often accompanies blistering. In certain extreme cases this combination manifests the formation of definite areas of ferrite in irons that otherwise retain considerable amounts of pearlite after enameling.

(10) Other physical and chemical characteristics, exclusive of obviously defective castings, have not, as yet, been associated with blistering.

XIV. Discussion

There are three major possibilities that could account for blistering, all based on the obvious fact that the blisters are caused by gas entrapped in the enamel: (1) The reaction producing the gas may have taken place within the enamel itself. (2) A reaction between the metal and the enamel may have given off a gas. (3) Gases originating within the metal itself may have been driven out into or through the enamel.

The Bureau of Standards[3] identified the offending gases as oxides of carbon. This fact would seem to eliminate the first possibility (1), the carbon in the iron being the only carbon available.

The second possibility is not so readily disposed of. Carbon is available in the surface of the iron and oxygen in the air. Reactions involving them and the enamel could take place, at least theoretically, which might generate carbon-oxide gases as products of reaction. But the admittedly meager evidence at hand seems to suggest that the second possibility is less probable than the third.

Based on the above eliminations, it becomes necessary to consider carbon oxide gases originating in the metal as the possible cause of blistering.

Again referring to the work of the Bureau[4] it is evident that the oxidation of carbon in the iron to carbon monoxide and carbon dioxide can be responsible for the generation of the blister-forming gases. If these gases escape during the early stages of firing no trouble results. If, due to the slow rate of breaking down of the cementite, or the retarding effect of a dense surface layer, the escape of these gases is delayed until the enamel has reached such a physical state as to render impossible penetration of the gases through the enamel and the healing of the resulting openings, blistering is experienced. These findings by the Bureau are definitely substantiated by the present work.

In promoting blistering the surface layer may function in either of two ways, possibly both: It may contain carbon in such a state as to be readily susceptible to oxidation; or it may offer resistance to gases from within the casting which, with the surface layer removed, are afforded a better opportunity to escape prior to the development of the critical consistency of the enamel as to gas entrapment. There is ample evidence in several instances to show that gas from the interior of the iron may escape in such a manner as to cause severe blistering even with the surface layer removed.

Relatively high silicon, low total carbon, and rapid annealing during the enameling operation are conditions which seem to promote freedom from blistering, at least in wet-process enameling. The importance of accurate foundry control is obvious though appreciated by but a relatively small number of companies.

Another factor which is definitely indicated as a potential cause of blistering is the presence of iron oxide in the casting. Cases beyond the scope of the present investigation are on record in which ferrous oxide determinations by the iodine-solution method have given values between

[3] Research Paper, No. 179, pp. 804–805.
[4] Research Paper, No. 179, p. 805.

1.00 and 2.00% on badly blistering irons. The employment of emergency measures claimed to reduce oxide has brought the determined values down with the elimination of blistering. Figures below 0.50% have seemed safe. In some of these cases it is claimed that pig iron has been a source of oxide while in others poor cupola practice, especially the improper use of steel scrap, has been held responsible.

The present work indicates that segregations of iron oxide, so small in amount as to escape detection by the use of the iodine method on general drillings, may be an important factor in blistering. Metallographic evidence has pointed out the formation of ferrite with the absence of corresponding graphite in areas high in intergranular iron oxide. The development of this condition has, no doubt, been accompanied by the generation of oxide of carbon gases.

An explanation of the "Manson effect" which would be in line with present considerations is that the violent passing of gases through a relatively thin layer of fluid enamel causes the phenomenon.

Two further phases of the problem can not be passed without attention: (1) that a given iron cast in thicker section blistered worse than when thin; and (2) the severe blistering of iron did not break down at all due to the heat of enameling.

Metallographic evidence in Figs. 11 and 13 as compared with Figs. 12 and 16 suggests a coarser structure and a greater amount of oxide in the thicker iron. Analytical data indicate a lesser degree of annealing with the thicker iron. Both of these observations are in line with the noted differences in blistering. Why they should be associated with variations in thickness as cast is not clear. The coarse pearlitic structure in Figs. 16 and 17 should not be overlooked.

If annealing liberates carbon, which is at least temporarily in a very active state and hence subject to oxidation, it is clear that irons that anneal slowly with reference to the firing of the enamel would be more liable to produce blistering than those annealing quickly. But a logical inference would be that irons which do not anneal to any appreciable degree would be nonblistering. Evidence is to the contrary: the most pronounced blistering and "Manson effect" have taken place on this type of iron, the removal of the surface layer making no apparent difference. This is another phase of the problem calling for further study.

The work covered is not sufficient in scope to warrant strong assertions. Certain possibilities have been indicated, which, in the judgment of the Committee, are of enough value to be published. It is hoped that they may be carefully considered and criticized, and that additional observations will afford evidence to substantiate and amplify the ideas or to lead to the formation of more correct and constructive theories.

Acknowledgment The Committee is under obligation to the several persons who submitted samples that made this investigation possible and to Mr. Comstock for his excellent assistance in connection with metallographic studies.

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DISCUSSION

By A. I. Krynitsky and W. N. Harrison

No specific set of conditions seems universally to accompany the phenomenon of blistering.

(1) Oxidation of Carbon The theory which appears to be confirmed by the data in this report may be summarized as that of the oxidation of carbon, resulting in the evolution of carbon dioxide and monoxide gases at a critical stage of the enameling process during which the enamel is capable of entrapping these gases. Such an explanation demands one or more sources of (*a*) active carbon and (*b*) available oxygen. Among the possible sources there may be enumerated for carbon (1) nascent carbon formed in the breakdown of combined carbon, and (2) very fine or colloidal graphite; and for oxygen (1) air, (2) oxide constituents of the enamel, and (3) iron oxide.

Especial interest attaches to Fig. 8, showing finely dispersed particles of graphite and a decarburized surface layer, and to Fig. 10, showing massive ferrite in the region of the streaks of iron oxide. Both of these figures indicate the reaction of an active source of carbon with an available source of oxygen. Whether the requisite combined carbon is derived from free cementite or from that of a pearlitic matrix is a question which has no bearing upon the basic conception.

(2) Source of Oxygen One of the most important sources of oxygen is air. Experiments conducted under conditions analogous to those of practice did not appear to support the hypothesis that the enamel is the chief source of oxygen when a ground coat is used, although the occurrence of some surface reaction was strongly indicated,[5] and the probability that iron oxide may be significant, at least on occasion, was recognized.[6]

The same irregular evidence which prevented selecting specific sources of carbon and oxygen as exclusively responsible for blistering is again apparent in this report. Typical examples of data which at first glance appear contradictory, but which nevertheless can be harmonized with the general theory, may readily be found. Thus, removal of the original surface layer of the castings is usually effective in eliminating or greatly reducing blistering, but is not always so. Blistering is sometimes accompanied by the presence of a mainly pearlitic structure before enameling, which largely breaks down during the enameling operation, but this reaction does not appear to be always the exact source of active carbon.

Furthermore, it appears entirely possible that a "nonblistering" iron may give off more gas, at least during certain stages of the enameling process, than a "blistering" iron. Other illustrations could be given, but the above will suffice to show the anomalous nature of much of the data which have so far been obtained.

(3) Varying Degree of Stability of Combined Carbon Many of these apparent inconsistencies are united when explained by the assumption that variations in the degree of stability of the cementite and in the fineness of the graphite furnish the key to blistering behavior.

Considerable data are on record to support the idea that there are two kinds of nonblistering iron, one in which a small amount of combined carbon is present in the surface layer, and the other in which the cementite is so stable that it takes a relatively long time to break it down into ferrite and temper carbon.[7] It may happen, therefore, that a thinner casting will enamel better than a thicker one, depending upon such conditions as the degree of massiveness of the cementite formation, the presence or absence of elements which tend to stabilize cementite, superheating of the melt, and other factors.

The Committee is correct in the thought that cementite may have that intermediate degree of stability which is most conducive to blistering, *i.e.*, it is subject to decomposition at such a rate that there is a fairly slow but continuous evolution of gas for a relatively long period of time. Although the iron oxide film in Case E is emphasized in the Committee Report as a cause of the blisters, it may be noted that this iron before enameling contained hard spots. These hard spots might well have contributed largely to the localized blistering which occurred on enameling and on re-enameling, always in the same place, if it is assumed that they represent the intermediate, blister-forming degree of stability.' The cases in which removal of the original surface layer of the castings failed to eliminate blistering may also be explained by the relative degree of stability of

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[5] Bur. Stand., *Jour. Research*, 4 [June], 792–93 (1930).
[6] *Ibid.*, pp. 764 and 797.
[7] Committee Report, metallographic discussion of case E.

the combined carbon throughout the castings and also by the fineness of structure of the graphite. The uniformly pearlitic structure and extremely fine graphite that characterize the heat-resisting pearlitic iron which blisters throughout its cross-section are in accord with such a conception.

(4) Effect of Varying Cupola Practice There is a belief that blast-furnace operating conditions confer upon pig iron characteristics which persist through subsequent melting in the cupola and affect the properties of castings made from it.[8] Two pig irons may have the same chemical compositions, but because their compound composition is different the properties of castings made from them may be different.[9]

(5) Steel Scrap Blistering castings in Cases A, B, and E are definitely stated to come from melts of iron containing steel scrap. No information on that score was available in Case C, and the statement of practice in Case F does not definitely preclude the use of steel scrap. In Case A satisfactory results were obtained before steel scrap was used, and after it was eliminated. In Case B the cupola in which steel scrap was used gave blistering iron and the one in which no steel scrap was used gave satisfactory iron.

Schaal at the Cleveland Meeting, 1931, gave illustrations of blistering on steel scrap castings.

Additional expressions concerning this and other factors having a direct bearing upon the report under discussion are contained in a paper given before the American Foundrymen's Association.[10]

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[8] A. L. Boegehold, "Blast-Furnace Operation Affects Quality of Pig Iron and Castings," *Foundry*, April, May, and June (1930).

[9] R. S. McCaffery, "The Cause of Variations in Pig-Iron Qualities," *Trans. Amer. Foundrymen's Assn.* (1927).

[10] A. I. Krynitsky and W. N. Harrison, *Trans. and Bull. Amer. Foundrymen's Assn.*, p. 332, August (1930); discussion, p. 369.

METHOD OF BRICK CONSTRUCTION WHICH INSURES WATER-TIGHT WALLS*

By R. H. Minton

I. Introduction

During the past year there has been developed a mechanical process to make brick walls waterproof, which has nothing in common with the present methods of waterproofing.

The sealed joint process makes it possible to erect walls that will be waterproof permanently, the mortar joint being sealed mechanically and not chemically. The wall is water-tight against rain and driving winds, and withstands the contraction and expansion from extremes of temperatures.

II. Description

(1) The Brick The specially made brick have a continuous V-shaped groove $^3/_8$ inch deep, running the length of the brick top and bottom (also in each end), and centered longitudinally.

When the brick are placed in a wall end to end, there is a continuous

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* This paper was written by the late R. H. Minton shortly before his death in December, 1931. Presented at the Annual Meeting, American Ceramic Society, Washington, D. C., February, 1932 (Structural Clay Products Division). See also *The Clay Worker*, 96 [5], 285 (1931).

horizontal groove on the upper side and a corresponding groove on the lower side, running the length of the wall. The vertical grooves in the ends of the brick align with each other and connect with continuous horizontal grooves above and below. When one course of these brick is laid on top of another course, the horizontal continuous groove in the upper side of the lower course aligns with the horizontal continuous groove in the lower face of the course of brick immediately above and resting on it.

Into the horizontal and vertical grooves there is inserted in the brick, after it has been laid up in the wall, an L-shaped piece of stiff noncorrosive alloy.

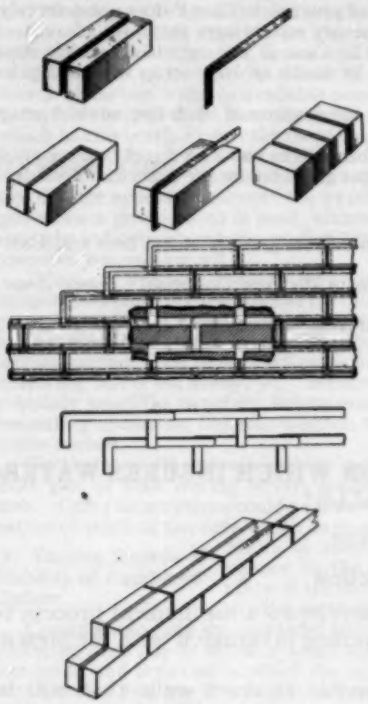

FIG. 1

(2) The Metal Subject to the kind of brick to be used and the type of wall required, this special L-shaped piece of metal will have different proportions. For ordinary size brick, however, this piece of metal will be 12 inches long and 1 inch wide, with the L-shaped projection on one end, $3^1/_2$ inches long. The dimensions of the metal strip will allow for $^1/_4$-inch mortar joints in a completed wall.

(3) Use of Strip The brick mason lays the brick in the usual way, then inserts one of the L-shaped strips in the horizontal groove, sliding the strip into place so that the L projection hooks into the vertical groove in the end of the brick. Mortar is spread and the next brick is laid and shoved into place. The metal is then hooked into this second brick.

In discussing the sealed joint thus far, only plain walls have been considered. To turn corners, there is a special corner brick. Where flemish bond is used, a special header is supplied.

III. Special Metal Reinforcement

The L-shaped hook on the end of the metal strip, being vertical, forms a permanent lock or key between the ends of the two abutting brick. The metal strip running the length of the brick forms a permanent lock or key with the halves of the two brick in the course immediately above it. The brick is 8 inches long. Therefore, lengthwise, the strip (12 inches long) overlaps the strips in the two brick abutting it on either end. The L-shaped hook goes down and overlaps the horizontal metal strip in the course below. So when the wall is completed, these metal-strip inserts form a mesh reinforcement vertically and horizontally.

IV. Self-Alignment

The sealed-joint construction obviates continuous use of the level and plumb-bob although it does not eliminate them entirely. Since in effect the sealed joint is mechanical, it forces the brick to level and align themselves automatically. Occasionally the mason, to check his work, will study his results with the use of the level and plumb-bob.

V. Report of Tests

Two hollow brick chimneys were built, each 36 inches high by 21 inches square, with the same mortar on the same day. One was laid up with sealed joint brick and strips and the other without. The first held water for three months. (Water lost by evaporation was supplied daily.) The second leaked gallons daily through the mortar joints.

WATER-PRESSURE TEST (All walls one brick wide)

Panel 1: Brick wall ordinary construction; 3/4 inch joint; water passes through mortar joints in less than 10 minutes.

Panel 2: Sealed-joint grooved brick without metal strips; 1/2 inch joint; water passes through mortar joints in about 1 1/2 hours.

Panel 3: Brick wall with sealed joint; 1/2 inch joint; water does not pass through the mortar joints nor through the brick.

Panel 4: Hard-fired Harvard brick ordinary construction; 3/8 inch joint; water passes through wall at mortar joints in less than 15 minutes.

Panel 5: Face buff brick wall ordinary construction; 3/8 inch joint; water passes through mortar joints within 30 minutes.

Panel 6: Buff face brick wall; this wall most carefully laid with water-resistant mortar; 1/2 inch joint; water came through wall slightly in about 1 1/2 hours; considerably in 2 1/2 hours.

Panel 7: Sealed-joint construction (cut out joint in back); 1/2 inch joint; water does not penetrate to the back of this wall after a test of several hours; at the point where the joint is exposed no water can be found.

Panel 8: Sealed-joint construction colonial brick; 1/2 inch joint; joints resist water indefinitely; this exhibit is made up of brick having a higher absorption than the usual face brick and in time these brick allow the water to go through and dampen the wall inside.

Panel 9: Dry-pressed brick without sealed joint; 3/8 inch joint; wall started to dampen within a few minutes and water came through considerably in less than 1 hour.

Further tests were made later on a panel parged with the same mortar as used in the joints. Water came through this panel at the edges in thirty minutes and after six hours spraying the wet portions were quite extended at the edges and in the center of the panel.

Another panel was parged on the two upper quarters with mortar containing well-known chemical waterproofing compounds with the following results:

Within five minutes water came through the mortar joints below the parged portions. After about thirty minutes both waterproof coatings began to absorb water along the lower edges. After six hours of spraying the center field of the panels was also wet.

VI. Conclusion

Although the parging of walls prevents leaking longer than where not used these tests do not indicate that such walls are water-tight.

If the parging could be removed intact from the walls it probably would be found that in certain spots it does not form complete contact with the wall, leaving places where water can collect. Furthermore, even the so-

called waterproofed mixtures are not proof against absorption and penetration of water.

Waterproofing of the mortar and parging of the walls do not seem of great value where there is movement of the walls. If the brick joints are broken by movement it is probable that the parging cracks also and allows free leakage.

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ACTIVITIES OF THE SOCIETY

JOINT COMMITTEE ON REFRACTORIES

The following notice has been issued to the affiliated organizations and committee members of the Joint Committee on Foundry Refractories, American Foundrymen's Association, by L. C. Hewitt, general chairman of the Committee. The purpose of the notice is to inform members of matters taken up at the meeting of the Committee held in Detroit, May 3.

(1) A matter of particular importance was the report of the Sub-Committee on the Gray Iron Industry, pertaining to simplification of cupola and tapout blocks.

Through the auspices of the U. S. Department of Commerce, this particular phase of committee work was discussed at a general conference to which producers and consumers were invited. In this conference it was developed that the existing conditions of the foundry industry make necessary the inclusion of smaller sizes of cupola blocks than those previously considered. Other than this addition, the recommendations were approved and the entire phase will be presented later to the industry through the Department of Commerce.

(2) The Sub-Committee on Survey and Standardization for the steel casting industry, of which Mr. Payne is Chairman, summarized the situation pertaining to the matter of tolerances for side-wall and roof refractories of direct-arc electric-melting furnaces. Reasons were given for the apparent wide tolerances that can be allowed for the side-wall refractories as compared to those for roofs.

The Committee plans to work out a procedure for a method of roof installation due to the fact that in respect to refractory life the matter of installation is equally important with size and shape.

(3) The Sub-Committee on the Nonferrous Industry, of which Mr. St. John is Chairman, submitted a comprehensive detail survey report, which will be published later. Some objections were raised relative to the inclusion of certain items in this report, such as trade names of various furnaces and refractories. Reference to trade names of refractory materials was omitted in the approved report.

LOCAL SECTION NEWS

Baltimore-Washington Section

The officers for the Baltimore-Washington Section for the 1932–1933 season are as follows:

Chairman, R. F. Geller, Bureau of Standards, Washington, D. C.
Vice-Chairman, Richard H. Turk, Porcelain Enamel & Mfg. Co., Baltimore, Md.
Secy.-Treasurer, W. R. Lester, Maryland Glass Corp., Baltimore, Md.
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Pacific-Northwest Section

Members of the Pacific-Northwest Section held a dinner meeting on June 24 in honor of Emerson P. Poste, President of the AMERICAN CERAMIC SOCIETY. Mr. Poste gave an instructive talk on the conditions and aims of the SOCIETY, followed by a discussion of enameled metal problems. Members who attended this meeting are as follows: Frank and Arthur Houlahan, Paul S. MacMichael, Wurth Kriegel, J. L. Davies, T. E. Nicholson, F. M. Kettenring, George E. Middleton, Ross D. Plank, Fred H. Jahn, Samuel Geijsbeek, Kenneth Johnson, Gordon Richardson, and Hewitt Wilson.

NECROLOGY

Dr. George K. Burgess

Dr. George K. Burgess died suddenly on July 2. He had been ill a few months previously but apparently was regaining his health and vigor. As Director of the Bureau of Standards, Dr. Burgess was directly in touch with a large amount of fundamental and empirical ceramic research. He influenced the productive coöperations which the several

ceramic groups had with the Bureau, and he was responsible to a large extent for the advisory committees which were from time to time set up.

Always open-minded, sympathetic, and mild mannered, he nevertheless was direct, forceful, and creative. He was a director, in the fullest sense of the word, of the world's largest research organization, quickly deciding and acting on what he determined from consultations was the desires and needs of the public.

G. K. BURGESS

Dr. Burgess will be missed by many scientific and industrial associations. He was active in several of these, frequently in an official capacity, and as often as he found it possible, in committees. His advice was sought and freely given in a wide variety of scientific and technical fields. Dr. Burgess will be missed by all the ceramic associations.

The following sketch is taken from Who's Who in America:

George Kimball Burgess, physicist, was born in Newton, Mass., January 4, 1874. *Degrees:* S.B., Mass. Institute of Technology, 1896; D.Sc., Paris, 1901; Honorary D.Engr., Case School of Applied Science, 1923, Lehigh Univ., 1925. He taught Physics at Mass. Inst. Tech., Univ. of Mich., 1900–1901, and Univ. of Calif; associate physicist, Bureau of Standards, Washington, D. C., 1903–1913; physicist and chief of division of metallurgy, same Bureau, 1913–1923; director of the Bureau of Standards, 1923 until his death; member of various committees connected with it, and engaged in pyrometric and metallographic researches. In addition to translations of Le Chatelier's High Temperature Measurements with additions, 1901, 1904, and Duhem's Thermodynamics and Chemistry, 1903, he was the author of the following works: Recherches sur la constante de Gravitation, 1901; Experimental Physics (freshman course), 1901; The Measurement of High Temperatures (with H. Le Chatelier), 1912. He was a member of several foreign and many American technical societies.

Joseph A. Nagle

Joseph A. Nagle, general manager of the Brunt Tile & Porcelain Co., Columbus, Ohio, died of cerebral hemorrhage on June 23. Mr. Nagle had been affiliated with the porcelain company for eleven years and for four years was superintendent of the Carl Co., at Macon, Ga. Mr. Nagle had been a member of the AMERICAN CERAMIC SOCIETY since 1920 and became an active member in 1923.

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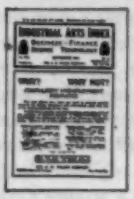

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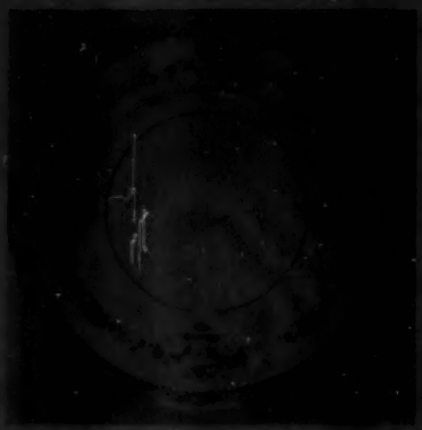

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